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MERAMEC RIVER MISSOURI

COMPREHENSIVE BASIN STUDY

VOLUME V

APPENDIX E—PROJECT DESIGNS AND COST ESTIMATES

APPENDIX F—HYDROPOWER

ORIGINAL CONTAINS COLOR PLATES: ALL DDC REPRODUCTIONS WILL BE IN BLACK AND WHITE

U. S. ARMY ENGINEER DISTRICT, ST LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

JANUARY 1964

ORIGINAL CONTAINS COLOR PLATES: ALL DDC REPRODUCTIONS WILL BE IN BLACK AND WHITE

(6) COMPREHENSIVE REPORT

MERAMEC RIVER, [redacted]
MISSOURI

Comprehensive Basin Study.

Volume V.

APPENDIX F.

PROJECT DESIGNS AND COST ESTIMATES.

Appendix F. Hydropower.

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TABLE OF CONTENTS

Paragraph	Subject	Page
	SECTION I - GENERAL	
1.	SCOPE	E-1
2.	DESIGN REQUIREMENTS	E-1
3.	SPILLWAY DESIGN FLOOD	E-1
4.	FREEBOARD REQUIREMENTS	E-1
5.	OUTLET CAPACITIES	E-1
6.	RESERVOIR LEVELS	E-2
7.	LANDS REQUIRED	E-2
8.	RESERVOIR CLEARING	E-2
9.	RELOCATIONS	E-2
	a. Roads	E-2
	b. Railroads	E-2
	c. Pipelines	E-2
	d. Cemeteries	E-3
	e. Power and telephone lines	E-3
10.	RECREATION	E-4
11.	PHYSICAL DATA	E-4
12.	RESERVOIRS	E-4
13.	DAMSITES	E-4
14.	GEOLOGY, SOILS, AND MATERIALS	E-6
15.	DAM DESIGN	E-6
	a. Embankment	E-6
	b. Spillways	E-6
16.	ESTIMATES OF RESERVOIR FIRST COSTS	E-6
17.	PROJECTS	E-7
	SECTION II - DESCRIPTION OF MAIN STREAM RESERVOIRS	
18.	GENERAL	E-8
19.	PINE FORD RESERVOIR (2A)	E-8
	a. Location	E-8
	b. Design details	E-8
	c. Electrical features	E-11
	d. Borings	E-11
	e. Relocations and alterations	E-11
	f. Land requirements	E-12
	g. Cost estimate	E-12
20.	WASHINGTON PARK RESERVOIR (5)	E-13
	a. Location	E-13
	b. Design details	E-13
	c. Electrical features	E-14
	d. Borings	E-14
	e. Relocations and alterations	E-14
	f. Land requirements	E-15
	g. Cost estimate	E-15

Paragraph	Subject	Page
21.	IRONDALE RESERVOIR (9)	E-16
	a. Location	E-16
	b. Design details	E-16
	c. Electrical features	E-17
	d. Borings	E-17
	e. Relocations and alterations	E-17
	f. Land requirements	E-18
	g. Cost estimate	E-18
22.	VIRGINIA MINES RESERVOIR (40)	E-18
	a. Location	E-18
	b. Design details	E-19
	c. Electrical features	E-19
	d. Borings	E-19
	e. Relocations and alterations	E-20
	f. Land requirements	E-20
	g. Cost estimate	E-21
23.	MERAMEC PARK RESERVOIR (17)	E-21
	a. Location	E-21
	b. Design details	E-21
	c. Electrical features	E-22
	d. Borings	E-22
	e. Relocations and alterations	E-23
	f. Land requirements	E-24
	g. Cost estimate	E-24
24.	SALEM RESERVOIR (27)	E-25
	a. Location	E-25
	b. Design details	E-25
	c. Electrical features	E-26
	d. Borings	E-26
	e. Relocations and alterations	E-26
	f. Land requirements	E-27
	g. Cost estimate	E-27
25.	UNION RESERVOIR (29)	E-28
	a. Location	E-28
	b. Design details	E-28
	c. Electrical features	E-28
	d. Borings	E-29
	e. Relocations and alterations	E-29
	f. Land requirements	E-30
	g. Cost estimate	E-30
	SECTION III - DESCRIPTION OF TRIBUTARY RESERVOIRS	
26.	GENERAL	E-31
27.	BIG RIVER SUB-BASIN	E-31
	a. Terre Bleue Creek Reservoir (I-30)	E-31
28.	MERAMEC RIVER SUB-BASIN (ABOVE MOUTH OF BOURBEUSE RIVER)	E-35
	a. Courtois Creek Reservoir (I-15A)	E-35
	b. Huzzah Creek Reservoir (I-14)	E-38

Paragraph	Subject	Page
	c. West Fork Huzzah Creek Reservoir (I-26)	E-40
	d. Benton Creek Reservoir (I-41)	E-42
	e. Little Dry Fork Creek Reservoir (I-23)	E-45
	f. Spring Creek Reservoir (I-28)	E-47
29.	BOURBEUSE RIVER SUB-BASIN	E-50
	a. Redoak Creek Reservoir (I-32)	E-50
	b. Little Bourbeuse River Reservoir (I-33A)	E-52
	c. Brush Creek Reservoir (I-35A)	E-55
	d. Peavine Creek Reservoir (I-21)	E-57
	e. Bourbeuse River Reservoir (I-38)	E-60
	SECTION IV - DESCRIPTION OF HEADWATER RESERVOIRS	
30.	GENERAL	E-63
31.	BIG RIVER SUB-BASIN	E-63
	a. Dry Creek Reservoir (H-3)	E-63
	b. Bates Creek Reservoir (H-9)	E-66
	c. Cabanne Course Reservoir (H-4)	E-68
	d. Coonville Creek Reservoir (H-40)	E-70
	e. Big River Reservoir (H-25)	E-71
32.	MERAMEC RIVER SUB-BASIN	E-73
	a. Brady Creek Reservoir (H-5A)	E-73
	b. Little Indian Creek Reservoir (H-8)	E-74
	c. Lost Creek Reservoir (H-10A)	E-76
33.	BOURBEUSE RIVER SUB-BASIN	E-77
	a. Birch Creek Reservoir (H-6)	E-77
	b. Winsell Creek Reservoir (H-11A)	E-79
	c. Boone Creek Reservoir (H-13A)	E-81
	d. Dry Fork Creek Reservoir (H-31)	E-82
	SECTION V - DESCRIPTION OF ANGLER-USE SITES	
34.	ANGLER-USE SITES	E-84
	SECTION VI - DESCRIPTION OF LOCAL PROTECTION PROJECTS	
35.	GENERAL	E-86
	a. Design criteria	E-86
	b. Design details	E-86
	c. Estimates of levee costs	E-86
36.	TELEGRAPH ROAD (AREA NO. 2)	E-86
	a. Location	E-86
	b. Design details	E-88
	c. Relocations	E-88
	d. Land requirements	E-88
	e. Cost estimate	E-88

Paragraph	Subject	Page
37.	STARLING AIRPORT ROAD (AREA NO. 4)	E-88
	a. Location	E-88
	b. Design details	E-88
	c. Relocations	E-89
	d. Land requirements	E-89
	e. Cost estimate	E-89
38.	BUTLER LAKES (AREA NO. 5)	E-89
	a. Location	E-89
	b. Design details	E-89
	c. Relocations	E-90
	d. Land requirements	E-90
	e. Cost estimate	E-90
39.	FENTON (AREA NO. 7)	E-90
	a. Location	E-90
	b. Design details	E-90
	c. Relocations	E-90
	d. Land requirements	E-91
	e. Cost estimate	E-91
40.	WEST WATSON ROAD (AREA NO. 8)	E-91
	a. Location	E-91
	b. Design details	E-91
	c. Relocations	E-91
	d. Land requirements	E-91
	e. Cost estimate	E-91
41.	WEISS AIRPORT (AREA NO. 9)	E-92
	a. Location	E-92
	b. Design details	E-92
	c. Relocations	E-92
	d. Land requirements	E-92
	e. Cost estimate	E-92
42.	VALLEY PARK (AREA NO. 11)	E-93
	a. Location	E-93
	b. Design details	E-93
	c. Relocations	E-93
	d. Land requirements	E-93
	e. Cost estimate	E-93
43.	PEERLESS PARK (AREA NO. 12)	E-93
	a. Location	E-93
	b. Design details	E-93
	c. Relocations	E-94
	d. Land requirements	E-94
	e. Cost estimate	E-94
43.	FOX CREEK (AREA NO. 17)	E-94
	a. Location	E-94
	b. Design details	E-94
	c. Relocations	E-95
	d. Land requirements	E-95
	e. Cost estimate	E-95

TABLES

Table No.	Title	Page
E-1	Initial recreation developments proposed	E-5
E-2	Main stream reservoir data sheet	E-9
E-3	Main stream reservoir land requirements	E-10
E-4	Road alterations at Pine Ford Reservoir (2A)	E-11
E-5	Land requirements of Pine Ford Reservoir (2A)	E-12
E-6	Cost estimate of Pine Ford Reservoir (2A)	E-13
E-7	Road alterations at Washington Park Reservoir (5)	E-14
E-8	Land requirements of Washington Park Reservoir (5)	E-15
E-9	Cost estimate of Washington Park Reservoir (5)	E-15
E-10	Road alterations at Irondale Reservoir (9)	E-17
E-11	Land requirements of Irondale Reservoir (9)	E-18
E-12	Cost estimate of Irondale Reservoir (9)	E-18
E-13	Road alterations at Virginia Mines Reservoir (40)	E-20
E-14	Land requirements of Virginia Mines Reservoir (40)	E-20
E-15	Cost estimate of Virginia Mines Reservoir (40)	E-21
E-16	Road alterations at Meramec Park Reservoir (17)	E-23
E-17	Land requirements of Meramec Park Reservoir (17)	E-24
E-18	Cost estimate of Meramec Park Reservoir (17)	E-24
E-19	Road alterations at Salem Reservoir (27)	E-26
E-20	Land requirements of Salem Reservoir (27)	E-27
E-21	Cost estimate of Salem Reservoir (27)	E-27
E-22	Road alterations at Union Reservoir (29)	E-29
E-23	Land requirements of Union Reservoir (29)	E-30
E-24	Cost estimate of Union Reservoir (29)	E-30
E-25	Tributary reservoir data sheet	E-32
E-26	Tributary reservoirs land requirements	E-33
E-27	Road alterations at Terre Bleue Creek Reservoir (I-30)	E-34
E-28	Land requirements of Terre Bleue Creek Reservoir (I-30)	E-34
E-29	Cost estimate of Terre Bleue Creek Reservoir (I-30)	E-35
E-30	Road alterations at Courtois Creek Reservoir (I-15A)	E-36
E-31	Land requirements of Courtois Creek Reservoir (I-15A)	E-37
E-32	Cost estimate of Courtois Creek Reservoir (I-15A)	E-37
E-33	Road alterations at Huzzah Creek Reservoir (I-14)	E-38
E-34	Land requirements of Huzzah Creek Reservoir (I-14)	E-39
E-35	Cost estimate of Huzzah Creek Reservoir (I-14)	E-39
E-36	Road alterations at West Fork Huzzah Creek Reservoir (I-26)	E-41
E-37	Land requirements of West Fork Huzzah Creek Reservoir (I-26)	E-41
E-38	Cost estimate of West Fork Huzzah Creek Reservoir (I-26)	E-42
E-39	Road alterations at Benton Creek Reservoir (I-41)	E-43
E-40	Land requirements of Benton Creek Reservoir (I-41)	E-44
E-41	Cost estimate of Benton Creek Reservoir (I-41)	E-44

Table No.	Title	Page
E-42	Road alterations at Little Dry Fork Creek Reservoir (I-23)	E-46
E-43	Land requirements of Little Dry Fork Creek Reservoir (I-23)	E-46
E-44	Cost estimate of Little Dry Fork Creek Reservoir (I-23)	E-47
E-45	Road alterations at Spring Creek Reservoir (I-28)	E-48
E-46	Land requirements of Spring Creek Reservoir (I-28)	E-49
E-47	Cost estimate of Spring Creek Reservoir (I-28)	E-49
E-48	Road alterations at Redoak Creek Reservoir (I-32)	E-51
E-49	Land requirements of Redoak Creek Reservoir (I-32)	E-51
E-50	Cost estimate of Redoak Creek Reservoir (I-32)	E-52
E-51	Road alterations at Little Bourbeuse River Reservoir (I-33A)	E-53
E-52	Land requirements of Little Bourbeuse River Reservoir (I-33A)	E-54
E-53	Cost estimate of Little Bourbeuse River Reservoir (I-33A)	E-54
E-54	Road alterations at Brush Creek Reservoir (I-35A)	E-56
E-55	Land requirements of Brush Creek Reservoir (I-35A)	E-56
E-56	Cost estimate of Brush Creek Reservoir (I-35A)	E-57
E-57	Road alterations at Peavine Creek Reservoir (I-21)	E-58
E-58	Land requirements of Peavine Creek Reservoir (I-21)	E-59
E-59	Cost estimate of Peavine Creek Reservoir (I-21)	E-59
E-60	Road alterations at Bourbeuse River Reservoir (I-38)	E-61
E-61	Land requirements of Bourbeuse River Reservoir (I-38)	E-61
E-62	Cost estimate of Bourbeuse River Reservoir (I-38)	E-62
E-63	Headwater reservoir data sheet	E-64
E-64	Headwater reservoirs land requirements	E-65
E-65	Land requirements of Dry Creek Reservoir (H-3)	E-66
E-66	Cost estimate of Dry Creek Reservoir (H-3)	E-66
E-67	Land requirements of Bates Creek Reservoir (H-9)	E-67
E-68	Cost estimate of Bates Creek Reservoir (H-9)	E-68
E-69	Land requirements of Cabanne Course Reservoir (H-4)	E-69
E-70	Cost estimate of Cabanne Course Reservoir (H-4)	E-69
E-71	Land requirements of Coonville Creek Reservoir (H-40)	E-70
E-72	Cost estimate of Coonville Creek Reservoir (H-40)	E-71
E-73	Land requirements of Big River Reservoir (H-25)	E-72
E-74	Cost estimate of Big River Reservoir (H-25)	E-72
E-75	Land requirements of Brady Creek Reservoir (H-5A)	E-73
E-76	Cost estimate of Brady Creek Reservoir (H-5A)	E-74
E-77	Land requirements of Little Indian Creek Reservoir (H-8)	E-75
E-78	Cost estimate of Little Indian Creek Reservoir (H-8)	E-75
E-79	Land requirements of Lost Creek Reservoir (H-10A)	E-77
E-80	Cost estimate of Lost Creek Reservoir (H-10A)	E-77
E-81	Land requirements of Birch Creek Reservoir (H-6)	E-78
E-82	Cost estimate of Birch Creek Reservoir (H-6)	E-79
E-83	Land requirements of Winsell Creek Reservoir (H-11A)	E-80
E-84	Cost estimate of Winsell Creek Reservoir (H-11A)	E-80
E-85	Land requirements of Boone Creek Reservoir (H-13A)	E-81
E-86	Cost estimate of Boone Creek Reservoir (H-13A)	E-82

Table No.	Title	Page
E-87	Land requirements of Dry Fork Creek Reservoir (H-31)	E-83
E-88	Cost estimate of Dry Fork Creek Reservoir (H-31)	E-83
E-89	Angler-use sites	E-85
E-90	Pertinent data, local protection	E-87
E-91	Cost estimate of Telegraph Road (Area No. 2)	E-88
E-92	Cost estimate of Starling Airport Road (Area No. 4)	E-89
E-93	Cost estimate of Butler Lakes (Area No. 5)	E-90
E-94	Cost estimate of Fenton (Area No. 7)	E-91
E-95	Cost estimate of West Watson Road (Area No. 8)	E-92
E-96	Cost estimate of Weiss Airport (Area No. 9)	E-92
E-97	Cost estimate of Valley Park (Area No. 11)	E-93
E-98	Cost estimate of Peerless Park (Area No. 12)	E-94
E-99	Cost estimate of Fox Creek (Area No. 17)	E-95

PLATES

Plate No.	Description
E-1	Meramec River Basin, Reservoir Sites Selected for Study
E-2	Pine Ford Reservoir
E-3	Pine Ford Dam, Design Details
E-4	Washington Park Reservoir
E-5	Washington Park Dam, Design Details
E-6	Irondale Reservoir
E-7	Irondale Dam, Design Details
E-8	Virginia Mines Reservoir
E-9	Virginia Mines Dam, Design Details
E-10	Meramec Park Reservoir
E-11	Meramec Park Dam, Design Details
E-12	Meramec Park Dam, Location of Borings
E-13	Salem Reservoir
E-14	Salem Dam, Design Details
E-15	Union Reservoir
E-16	Union Dam, Design Details
E-17	Union Dam, Location of Borings
E-18	I-30, Terre Bleue Creek Reservoir
E-19	I-30, Terre Bleue Creek Dam, Design Details
E-20	I-15A, Courtois Creek Reservoir
E-21	I-15A, Courtois Creek Dam, Design Details
E-22	I-14, Huzzah Creek Reservoir
E-23	I-14, Huzzah Creek Dam, Design Details
E-24	I-26, West Fork Huzzah Creek Reservoir
E-25	I-26, West Fork Huzzah Creek Dam, Design Details
E-26	I-41, Benton Creek Reservoir
E-27	I-41, Benton Creek Dam, Design Details
E-28	I-23, Little Dry Fork Creek Reservoir
E-29	I-23, Little Dry Fork Creek Dam, Design Details

Plate No.	Description
E-30	I-28, Spring Creek Reservoir
E-31	I-28, Spring Creek Dam, Design Details
E-32	I-32, Redoak Creek Reservoir
E-33	I-32, Redoak Creek Dam, Design Details
E-34	I-33A, Little Bourbeuse River Reservoir
E-35	I-33A, Little Bourbeuse River Dam, Design Details
E-36	I-35A, Brush Creek Reservoir
E-37	I-35A, Brush Creek Dam, Design Details
E-38	I-21, Peavine Creek Reservoir
E-39	I-21, Peavine Creek Dam, Design Details
E-40	I-38, Bourbeuse River Reservoir
E-41	I-38, Bourbeuse River Dam, Design Details
E-42	Levee Protection System - Plan
E-43	Levee Protection System - Profiles

APPENDIX E

PROJECT DESIGNS AND COST ESTIMATES

SECTION I - GENERAL

1. SCOPE

This appendix contains the design and cost estimates of the physical features for each proposed element of the recommended comprehensive plan for development of water resources of the Meramec River Basin. Designs were made using general principles of accepted design practices described in engineering manuals of the Corps of Engineers, together with design criteria and basic data described in this appendix. Designs of the 12 headwater reservoirs included in this appendix were furnished by the U. S. Department of Agriculture, Soil Conservation Service.

2. DESIGN REQUIREMENTS

Basic data and information for such features as spillway design flood, diversion flows, various reservoir levels for storage requirements, downstream water demands, local protection, and hydroelectric power facilities, applicable to each reservoir and damsite included in the recommended comprehensive plan of development of water resources in the Meramec River Basin, have been developed and described in other appendices to this report. A brief statement of design requirements for ultimate project design follows.

3. SPILLWAY DESIGN FLOOD

Determination of the spillway design flood was accomplished by applying the design storm runoff to the inflow unit hydrographs at each reservoir site. A discussion of source data and routing procedures is contained in PARAGRAPH 70, APPENDIX C. Based on the spillway design flood and topography of the dam and spillway site, the most economical length for the spillway crest was selected.

4. FREEBOARD REQUIREMENTS

Preliminary estimates of freeboard requirements at each of the reservoirs indicated that in no case would minimum requirements be exceeded. Therefore, minimum freeboard requirements of 5 feet were set for all major and intermediate reservoir dams. Freeboard requirements for headwater dams were determined by the Soil Conservation Service.

5. OUTLET CAPACITIES

Outlet conduits through each of the dams were designed to have sufficient capacity to carry diversion flow during construction and meet minimum release requirements for downstream uses.

6. RESERVOIR LEVELS

Reservoir levels were those determined by storage allocations as described in SECTION VII of the main report. These levels are given in TABLES E-2, E-25, and E-63 of this appendix.

7. LANDS REQUIRED

Lands would be acquired in accordance with the Joint Army-Interior Reservoir Land Acquisition Policy, and estimates of additional lands required for reservoir-associated recreation, including fish and wildlife, are the result of coordinated studies by the Bureau of Outdoor Recreation, National Park Service, U. S. Forest Service, U. S. Fish and Wildlife Service, Missouri State Park Board, Missouri Conservation Commission, and the St. Louis District.

8. RESERVOIR CLEARING

Clearing will be required on all lands below an elevation of 5 feet above the normal pool and will include removal of trees, brush, fences, and existing buildings. Specific areas designated by recreation and fish and wildlife interests would require special clearing.

9. RELOCATIONS

a. Roads. Relocations of roads have been based on maintaining service now provided by the existing road network. The road relocation plan for individual reservoirs was selected after study of available data, including county road maps and traffic volume maps supplied by the Missouri State Highway Commission, U. S. Geological Survey maps, and information obtained on field trips to the reservoir areas. Missouri State Highway Commission design standards have been observed in all road relocations. Any roads relocated across a reservoir will be raised to an elevation of 3 feet above the top of the flood control pool, or, to the top of the joint-use pool in the absence of flood control. The road relocation plans shown on the individual reservoir maps have been coordinated with the Missouri State Highway Commission. The road relocations proposed are, in general, satisfactory to the Highway Commission. However, detailed surveys and studies, with the cooperation of the respective owners, will be necessary in working out final plans for relocations of existing roads and structures.

b. Railroads. No railroad alterations or relocations are required at any of the reservoirs.

c. Pipelines. Information available from maps of the gas and oil pipelines through the State of Missouri, prepared by the Missouri Division of Commerce and Industrial Development, indicates four pipelines passing through the Meramec Basin. The Gulf Refining Company, Shell Oil Company, Mississippi River Fuel Company, and Cherokee Pipeline Company

each own and operate a pipeline through the basin area. Information available from the above-mentioned companies shows that the Gulf Refining Company pipeline is affected by impoundments 2A (Pine Ford), 17 (Meramec Park), and I-41 (Benton Creek). The affected pipeline consists of two parallel 10-3/4-inch outside diameter by 0.365-inch wall thickness, steel pipes transporting crude oil from Tulsa, Oklahoma, to Ohio. The pipes are unwrapped and are cathodically protected with anodes. It is proposed to alter or relocate this line where necessary.

d. Cemeteries. There are a number of cemeteries located within the pool limits of the major and intermediate reservoirs. These have been located by map study and field reconnaissance. It is proposed to move these burials to higher ground, within the cemetery where possible. The existence of small unknown family plots is likely. Therefore, careful field reconnaissance will be necessary in the general design stage.

e. Power and telephone lines.

(1) There are eight power companies and eight telephone companies presently operating in areas which will be inundated by reservoirs proposed for construction under this plan. The eight power companies are: Arkansas-Missouri Power Company, Black River Electric Cooperative, Citizens Electric Corporation, Crawford Electric Cooperative, Intercounty Electric Cooperative, Missouri Power and Light Company, Sho-Me Power Corporation, and Union Electric Company. The eight telephone companies are: Bourbon, Fidelity, Meramec, Potosi, South Missouri, Southwestern Bell, Steelville, and United.

(2) It is planned that facilities presently providing service only to customers located within the limits of the flood control pool will be removed upon evacuation of these customers. Facilities which presently cross through the proposed reservoir sites, within the limits of the flood control pool, will be either raised in place or relocated, whichever is more practicable. Lines to be raised in place will provide minimum clearances as set forth in ER 1110-2-4401, "Clearances for Power and Communication Lines Over Reservoirs," and specifically as applicable to boats having projections not exceeding 15 feet above water. Facilities requiring relocation will, where practicable, be relocated so as to continue service to the customer from the original source. Construction of new facilities will be of the same type as existing facilities.

(3) All alterations of facilities will be accomplished through negotiated agreements between the Government and the respective companies. All work will be done by, or at the direction of, the utility companies.

(4) Estimates of costs associated with utility relocations are based upon information obtained from the previously mentioned companies.

10. RECREATION

Facilities for public recreational use at reservoirs are provided in accordance with Section 4 of the Flood Control Act approved 22 December 1944, as amended. A joint report prepared by the Bureau of Outdoor Recreation and National Park Service defined the scope of development required to meet the initial impact of visitation at each reservoir. The comparative recreational quality of each of the reservoirs was evaluated based on the assumption that the entire system would be in operation by the year 1970. Requirements for public use and scope of initial development were determined for each of the reservoirs. Initial recreational developments provided by the Corps of Engineers include access and circulation roads, boat launching ramps, parking areas, picnicking and tent campsites, beach areas, and provisions for potable water and sanitary facilities. TABLE E-1 shows initial recreation developments proposed at each of the 31 reservoirs. Facilities for typical picnic units and tent camp spaces consist of a picnic table with concrete pad and a barbecue brazier. A picnic shelter, central washhouse with showers, provision of potable water and distribution system, sanitary facilities, and access road and parking area will be provided for groups of picnic units and tent camp spaces as appropriate.

11. PHYSICAL DATA

The entire Meramec River Basin has been mapped by the U. S. Geological Survey. Topographic maps for the whole basin are available to a scale of 1:62,500. Large parts of the basin are also covered by topographic maps to a scale of 1:24,000. Meramec Park and Union Reservoirs were previously mapped by the Corps of Engineers to a scale of 1:12,000. U. S. Department of Agriculture Crop Stabilization aerial photographs are also available. In determining reservoir capacities and preparing maps for required relocations, the maps having the largest scale were used. All elevations shown are based on data from the topographic maps or from field surveys based on U. S. Geological Survey bench marks.

12. RESERVOIRS

Reservoir outlines shown on plates in this appendix have been drawn from the best available topographic maps. The extent of roads and utilities which would require relocation or raising was determined from the reservoir maps. Similarly, routes for relocated roads and utilities were determined, and estimates for such work were based on elevations and distances shown on the same map.

13. DAMSITES

At each damsite, except Meramec Park and Union, U. S. Geological Survey topographic maps were enlarged to the same scale as the aerial photographs, and then adjusted where necessary to agree with them.

TABLE E-1
Initial recreation developments proposed

Project	Boat launching ramps (2-lane)	Picnic units	Tent camp spaces	Acres of parking area	Beaches (500-2,000 feet of lake frontage)
Meramec Park	12	450	400	15.0	3
Salem	2	85	90	2.0	3
Irondale	2	100	90	2.0	3
Pine Ford	3	200	180	3.0	3
I-38	1	70	60	1.5	2
I-14	1	35	30	0.75	2
Union	3	170	150	4.0	3
I-23	1	40	35	0.75	2
Washington Park	1	30	25	0.75	3
I-15A	1	20	20	0.33	2
H-40	1	10	10	0.33	0
I-32	1	20	20	0.33	2
Virginia Mines	10	220	200	3.00	3
I-30	1	20	20	0.33	2
I-28	2	30	30	0.50	2
H-6	1	15	15	0.33	0
I-26	2	30	30	0.50	2
H-8	1	15	15	0.33	0
H-13	1	20	20	0.33	1
H-4	1	10	10	0.33	0
H-9	1	15	15	0.33	0
H-25	1	10	10	0.33	0
H-10	1	10	10	0.33	0
I-33A	1	20	20	0.33	2
I-35A	1	20	20	0.33	2
H-11	1	10	10	0.33	0
H-3	1	15	15	0.33	0
H-5	1	15	15	0.33	0
I-21	1	15	15	0.33	0
I-41	1	20	20	0.33	2
H-31	1	15	15	0.33	0

Damsites for Meramec Park and Union Dams were mapped for the 1949 report to a scale of 1 inch = 200 feet and were also used for site selection in this report. (PLATES E-12 and E-17).

14. GEOLOGY, SOILS, AND MATERIALS

APPENDIX D, "Geology, Soils, and Materials," contains detailed information on soil classification, general geology of the whole basin, results of subsurface investigation already undertaken, and availability of construction materials. The soil boring legend shown on PLATE D-4 and the rock boring legend shown on PLATE D-5 apply to all boring logs except those borings taken for the 1949 report of Meramec Park and Union damsites, which are classified by the system in use at that time.

15. DAM DESIGN

a. Embankment. All dams proposed in this report will be of the rolled-earth type, and all will have chute spillways. The top width of the embankment will be 35 feet for main stream dams, 30 feet for tributary dams, and 20 feet for headwater dams. The upstream slope of the dam embankment for main stream and tributary stream dams will be protected by a 24-inch thickness of rock revetment extending from the top of the dam down to the minimum conservation pool. The upstream slope of the headwater dams, designed by the Soil Conservation Service, is provided with 18 inches of rock revetment extending from the normal pool elevation down along the slope for a distance of 15 feet. Side slopes will vary and are presented by typical sections of each dam.

b. Spillways. Spillways will be of the chute type. For the purpose of this report, the reinforced concrete chute spillway design has been standardized. The crest width of the concrete spillways will be 200 feet for the main stream dams and 50 feet for the tributary dams. Spillways of three of the tributary dams will be grassed, with a concrete apron on the crest, and will vary in width from 365 feet to 1,110 feet. Stilling basins are provided to dissipate the energy of the discharging water. Spillways for eight headwater dams will be grassed and will vary in width from 75 feet to 250 feet; the other four will be concrete and will vary in width from 75 to 160 feet.

16. ESTIMATES OF RESERVOIR FIRST COSTS

Estimates of first costs for all reservoirs are based on the assumption that the United States will construct the dam and appurtenant works, acquire the necessary lands and improvements, and make such alterations and relocations of highways and utilities as are necessary for each of the reservoirs in the plan of improvement. Unit costs are based on July 1963 prices and, wherever possible, upon information available for comparable types of work under construction within the general area. Allowances for contingencies and maintenance during construction are included. First costs are presented in detail in APPENDIX T and are summarized herein.

17. PROJECTS

A brief description along with pertinent tables, plates, and cost estimates is included for each project. For purposes of this report, the projects have been arranged in five categories: main stream reservoirs, tributary reservoirs, headwater reservoirs, angler-use sites, and levees.

SECTION II - DESCRIPTION OF MAIN STREAM RESERVOIRS

18. GENERAL

TABLE E-2 gives pertinent data on the seven main stream reservoirs retained for economic analysis. TABLE E-3 summarizes land requirements.

19. PINE FORD RESERVOIR (2A) (PLATES E-2 and E-3)

a. Location. The Pine Ford Dam as proposed would be located on the Big River at mile 43.8 above its confluence with the Meramec River. The total drainage area above the site is 788 square miles. The intervening reservoirs, Washington Park and Irondale, would control 335 square miles of the total drainage area above Pine Ford Reservoir.

b. Design details.

(1) The proposed rolled-earth embankment will have a crest length of about 2,070 feet and rise approximately 141 feet high. The crown width at crest elevation of 637 feet will be 35 feet. The upstream slope of the embankment will be 1 on 3 to elevation 597 and 1 on 4 down to the valley floor. The downstream slope will be 1 on 3. Internal drainage for the embankment will be provided by a chimney drain and filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 531.

(2) A chute spillway will be of reinforced concrete founded on rock in the left abutment. It will consist of entrance bay, overflow section with crest at elevation 595, chute on a slope of 1 on 20 at upper end and 1 on 5 at lower end, and stilling basin with floor at elevation 472. The spillway will be 200 feet wide at the crest and in the chute, flaring to 300 feet in the stilling basin.

(3) The outlet works with invert at river bottom elevation of 496 feet will be founded on rock in the center of the valley. They will consist of a double 6'-3" x 11'-6" concrete cut-and-cover conduit, a stilling basin, and gate structure complete with service and emergency tractor gates for flood control releases. Three 54" x 54" power-operated water quality control gates will be placed between the top of the joint-use pool and the conduit. The gate structure will be surmounted by an operating house with access from the dam by a service bridge. See PLATE E-3.

(4) All the tractor gates will be operated by one hoist, rail-mounted in the upper level of the gate structure. The hoist will consist of a hand-operated bridge and trolley and an electrically powered hoist. The hoist will have a capacity of 65 tons and a lift of 141 feet.

TABLE E-2
Main stream reservoir data sheet

	Pine Ford (2A)	Washington Park (5)	Irondale (9)	Virginia Mines (40)	Meramec Park (17)	Salem (27)	Union (29)
Top dam elevation (m.s.l.)	637	737	887	592	736	1,039	682
Spillway crest elevation (m.s.l.)	595	706	860	556	701	1,008	651
Normal pool elevation (m.s.l.)	561	706	855	556	667	1,000	616
Minimum conservation pool elevation (m.s.l.) (100-year sediment capacity)	531	618	796	527	600	928	567
River bottom elevation (m.s.l.)	496	590	760	500	566	894	531
Drainage area above damsite	788	160	175	1,748	1,508	175	754
Storage (acre-feet)							
Total	285,000	147,200	161,000	110,300	1,000,000	161,200	528,000
Flood control	196,700	-	23,900	-	581,600	30,000	355,600
Joint-use	88,300	147,200	137,100	110,300	418,400	131,200	172,400
Sediment	12,000	5,600	5,800	9,000	18,200	6,000	11,900
Net joint-use	76,300	141,600	131,300	101,300	400,200	125,200	160,500
Pool areas (acres)							
Maximum spillway surcharge	15,500	5,500	8,000	9,800	35,000	6,500	22,500
Flood control pool	8,500	-	5,100	-	27,500	4,100	16,600
Normal pool	3,700	3,700	4,600	5,200	12,600	3,400	6,600
Minimum conservation pool	1,300	400	500	1,400	1,500	400	1,000
Dam dimensions							
Crest length (feet)	2,070	2,770	4,050	2,190	2,550	2,090	3,720
Base width (feet)	982	917	722	526	978	1,010	878
Volume (cubic yard)	9,189,000	5,016,000	1,273,000	1,300,000	3,380,000	3,428,000	2,597,000
Spillway							
Type	Chute	Chute	Chute	Chute	Chute	Chute	Chute
Length (feet)	200	200	200	200	200	200	200
Capacity (c.f.s.)	185,200	108,400	82,900	139,800	132,200	108,400	108,400
Maximum surcharge (feet)	37	26	22	31	30	26	26
Outlets*							
Number, size	2 - 6'3"x11'6"	1 - 5'3"x6'6"	1 - 5'3"x6'6"	4 - 6'9"x12'0"	3 - 6'9"x12'0"	1 - 5'3"x6'6"	2 - 6'0"x11'0"
Maximum controlled discharge (c.f.s.)	3,940	800	875	8,740	7,540	875	3,770
Minimum controlled discharge (c.f.s.)	378	105	101	721	614	88	213

*Outlets, controlled by tractor gates, are sized for diversion and have capacities exceeding bankfull capacity and minimum flow requirements.

TABLE E-3
Main stream reservoir land requirements
(acres)

Reservoir	Land required up to top pool elevation	Access land reqd. from top pool elev. back 300 ft. horizontal plus dam, spillway, and borrow areas	Land reqd. for initial CE recreation development	Land reqd. to replace state lands inundated	Land reqd. for land-based recreation in Clark National Forest	Land reqd. for relocations	Land reqd. for future recreation development and for mitigation of wildlife habitat losses	Total land requirements
Pine Ford #2A	8,500	6,600	1,100	800	-	40	2,700	19,740
Washington Park #5	3,700	2,300	500	-	-	130	600	7,230
Irondale #9	5,100	3,400	800	-	-	100	1,100	10,500
Virginia Mines #40	5,200	8,200	1,500	-	-	70	3,600	18,570
Meramec Park #17	27,500	11,800	3,700	1,300	-	200	4,400	48,900
Salem #27	4,100	2,800	700	-	-	80	1,900	9,580
Union #29	16,600	8,600	1,900	-	-	130	1,600	28,830
Total for main stream reservoirs	70,700	43,700	10,200	2,100	-	750	15,900	143,350

c. Electrical features. The gate hoist electrical equipment will consist of the following items: a high-torque, high slip, squirrel cage induction motor; a motor-operated shoe brake; and control equipment, consisting of controller, limit switch, and control station. The motors will be equipped with winding heaters. Control equipment inclosures will be of watertight, dust tight, and moisture-resisting construction. The gate-operating house will be electrically lighted to an average illumination of 10 foot-candles. A lightning protection system will be provided for the gate hoist structure.

d. Borings. Boring locations and estimated depth to firm rock are shown on sections presented on PLATE E-3. Logs of borings are shown on PLATE D-6. No indications of major adverse foundation factors have been disclosed by present investigations.

e. Relocations and alterations.

(1) Roads. The reservoir would necessitate building about 5.7 miles of new road and improving 2.7 miles of existing road. Cost estimates for the individual relocations as shown in the following table may be found in APPENDIX T.

TABLE E-4
Road alterations at Pine Ford Reservoir (2A)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
S-1	0.3	1.6	Raise Route H across main reservoir and Calico Creek arm.
S-2	0.3	-	Raise Route WW across Maupin Creek arm.
S-3	0.3	-	Raise Route WW across Ditch Creek arm.
S-4	0.5	-	Raise Route CC across reservoir.
S-5	0.3	-	Raise Route 21 across reservoir.
S-6	0.1	-	Raise Route 104 across arm of reservoir in Washington State Park.
C-1	-	1.8	Maintain access to area northeast of Kingston, Missouri.
C-2	0.9	-	Maintain access to area northeast of Kingston, Missouri.
A-1	-	2.3	Road across dam.

(2) Pipelines. There are two 10-inch parallel oil lines owned by the Gulf Refining Company which would be inundated by the reservoir. Twenty-four hundred feet of this dual line would require alteration to maintain present service.

(3) Power and telephone lines. Locations of power and telephone lines requiring alteration are not shown on the reservoir maps included with this report. Facility locations received from the various utility companies have been plotted on topographic maps, and from these mileage figures were determined. These maps are available for inspection in the St. Louis District. Approximately 40 miles of power distribution lines and 20 miles of telephone lines will require alteration due to construction of this reservoir.

(4) Cemeteries. A total of 75 graves was found by field reconnaissance. It is planned to relocate existing graves and headstones in all cemeteries within the pool to higher ground.

f. Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-5
Land requirements of Pine Ford Reservoir (2A)

Reservoir operation and construction	Acres
Below maximum flood pool	
Cleared land	4,200
Timberland	3,500
Existing stream	800
Above maximum flood pool (300' strip)	6,300
Dam and working areas	300
Rights-of-way for relocations	40
Subtotal	15,140
Additional land for recreation (others)	3,500
Additional land for recreation (CE)	1,100
Total	19,740

g. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-6
Cost estimate of Pine Ford Reservoir (2A)

Item	Cost
Lands and damages	$ 5,960,000
Relocations	5,663,000
Reservoir clearing	312,000
Dam and appurtenant works	7,758,000
Fish and wildlife facilities	10,000
Access road	364,000
Recreation facilities	900,000
Buildings, grounds, and utilities	217,000
Permanent operating equipment	176,000
Engineering and design	1,670,000
Supervision and administration	1,170,000
Total	$24,200,000

20. WASHINGTON PARK RESERVOIR (5) (PLATES E-4 and E-5)

a. Location. This site is located on Mineral Fork 5 miles above its confluence with the Big River at mile 60.6. It is just within the flood control pool of the lower Pine Ford Reservoir. The total drainage area above the site is 160 square miles.

b. Design details.

(1) The proposed rolled-earth embankment will have a crest length of about 2,770 feet and rise approximately 147 feet high. The crown width at crest elevation of 737 feet will be 35 feet. Upstream and downstream slopes of the embankment would be 1 on 3. Internal drainage for the embankment will be provided by a filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 618.

(2) The chute spillway will be of reinforced concrete founded on rock on the right abutment. It will consist of entrance bay, overflow section with crest at elevation 706, chute on a 1 on 4 slope, and stilling basin with floor at elevation 562. The spillway will be 200 feet wide at the crest converging to 150 feet in the chute and stilling basin for economy in cost.

(3) The outlet works with invert at river bottom elevation will be founded on rock in the center of the valley. They will consist of a 5'-3" x 6'-6" concrete cut-and-cover conduit, a stilling basin, and gate structure complete with service and emergency tractor

gates for flood control releases. Three 54" x 54" power-operated water quality control gates will be placed between the top of the joint-use pool and the conduit. The gate structure will be surmounted by an operating house with access from the dam by a service bridge.

(4) All the tractor gates will be operated by one hoist, rail-mounted in the upper level of the gate structure. The hoist will consist of a hand-operated bridge and trolley and electrically powered hoist. The hoist will have a capacity of 43 tons and a lift of 147 feet.

c. Electrical features. The gate hoist electrical equipment will consist of the following items: a high-torque, high slip, squirrel cage induction motor; a motor-operated shoe brake; and control equipment, consisting of controller, limit switch, and control station. The motors will be equipped with winding heaters. Control equipment inclosures will be of watertight, dust tight, and moisture-resisting construction. The gate-operating house will be electrically lighted to an average illumination of 10 foot-candles. A lightning protection system will be provided for the gate hoist structure.

d. Borings. Borings indicate moderate depths to rock along the entire axis of the dam. See PLATE E-5 for boring locations and PLATE D-7 for boring logs. Investigations indicated a feasible site with respect to foundations.

e. Relocations and alterations.

(1) Roads. The reservoir would necessitate building about 5.9 miles of new road and improving 3.4 miles of existing road. Cost estimates for the individual relocations as shown in the table below may be found in APPENDIX T.

TABLE E-7
Road alterations at Washington Park Reservoir (5)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
S-1	-	1.0	Relocation of Route 47 downstream of dam.
S-2	-	0.5	Raise Route F across reservoir.
C-1	3.3	3.0	Maintain east-west service on north side of reservoir.
C-2	-	1.4	Maintain road net north of reservoir.
C-3	0.1	-	Maintain access to area south of Clear Creek.

(2) Pipelines. There are no pipeline crossings of Washington Park Reservoir which require alteration or relocation.

(3) Power and telephone lines. Approximately 12 miles of power distribution lines and 7 miles of telephone lines will require alteration due to construction of this reservoir.

(4) Cemeteries. No graves were found by field inspection; however, a liberal allowance has been made in the cost estimate to cover this item. It is planned to relocate existing graves and headstones in all cemeteries within the pool to higher ground.

f. Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-8
Land requirements of Washington Park Reservoir (5)

Reservoir operation and construction		Acres
Below maximum pool		
Cleared land		1,200
Timberland		2,200
Existing streams		300
Above maximum pool (300' strip)		1,900
Dam and working areas		400
Rights-of-way for relocations		130
	Subtotal	6,130
Additional land for recreation (others)		600
Additional land for recreation (CE)		500
	Total	7,230

g. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-9
Cost estimate of Washington Park Reservoir (5)

Item	Cost
Lands and damages	$ 1,145,000
Relocations	2,593,000
Reservoir clearing	138,000
Dam and appurtenant works	9,705,000
Fish and wildlife facilities	10,000
Access road	234,000

TABLE E-9 (Cont'd)

Item	Cost
Recreation facilities	$ 120,000
Buildings, grounds, and utilities	217,000
Permanent operating equipment	108,000
Engineering and design	1,420,000
Supervision and administration	1,110,000
Total	$16,800,000

21. IRONDALE RESERVOIR (9) (PLATES E-6 and E-7)

a. Location. This site is located on the upper Big River at mile 117.1. The total drainage area above the site is 175 square miles.

b. Design details.

(1) The proposed rolled-earth embankment will have a crest length of about 4,050 feet and rise approximately 127 feet high. The crown width at crest elevation of 887 feet will be 35 feet. The upstream slope of the embankment will be 1 on 3. The downstream slope will be 1 on 2.25 down to elevation 837 and 1 on 2.5 down to the valley floor. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 796.

(2) The chute spillway will be of reinforced concrete founded on rock in the left abutment. It will consist of entrance bay, overflow section with crest at elevation 860, chute on 1 on 4 slope, and stilling basin with floor at elevation 743. The spillway will be 200 feet wide at the crest converging to 150 feet in the chute and stilling basin for economy in cost.

(3) The outlet works with invert at river bottom elevation will be founded on rock in the right of the valley. They will consist of a 5'-3" x 6'-6" concrete cut-and-cover conduit, a stilling basin, and gate structure complete with service and emergency tractor gates for flood control releases. Three 54" x 54" power-operated water quality control gates will be placed between the top of the joint-use pool and the conduit. The gate structure will be surmounted by an operating house with access from the dam by a service bridge.

(4) All the tractor gates will be operated by one hoist, rail-mounted in the upper level of the gate structure. The hoist will consist of a hand-operated bridge and trolley and an electrically powered hoist. The hoist will have a capacity of 82 tons and a lift of 127 feet.

c. Electrical features. The gate hoist electrical equipment will consist of the following items: a high-torque, high slip, squirrel cage induction motor; a motor-operated shoe brake; and control equipment, consisting of controller, limit switch, and control station. The motors will be equipped with winding heaters. Control equipment inclosures will be of watertight, dust tight, and moisture-resisting construction. The gate-operating house will be electrically lighted to an average illumination of 10 foot-candles. A lightning protection system will be provided for the gate hoist structure.

d. Borings. Locations of borings and estimated depth to firm rock are shown on PLATE E-7. Boring logs may be found on PLATE D-8. Investigations indicate a feasible site with respect to foundations.

e. Relocations and alterations.

(1) Roads. The reservoir would necessitate building about 5.7 miles of new road and improving 3.3 miles of existing road. Cost estimates for the individual relocations as shown in the table below may be found in APPENDIX T.

TABLE E-10
Road alterations at Irondale Reservoir (9)

Designation	Length of *alteration* (miles)	Length of *new road* (miles)	Description
S-1	-	2.7	Relocate Route 21 across reservoir.
S-2	2.0	-	Raise Route 32 across reservoir.
S-3	1.3	1.6	Maintain east-west service north of reservoir.
C-1	-	0.4	Maintain road net south of Wallen Creek.
A-1	-	1.0	Road across dam.

(2) Pipelines. There are no pipeline crossings of Irondale Reservoir which require alteration or relocation.

(3) Power and telephone lines. Approximately 7 miles of power distribution lines and 5 miles of telephone lines will require alteration due to construction of this reservoir.

(4) Cemeteries. A total of 20 graves was found by field reconnaissance. It is planned to relocate existing graves and headstones in all cemeteries within the pool to higher ground.

f. Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-11
Land requirements of Irondale Reservoir (9)

Reservoir operation and construction		Acres
Below maximum flood pool		
Cleared land		2,500
Timberland		2,200
Existing streams		400
Above maximum flood pool (300' strip)		3,000
Dam and working areas		400
Rights-of-way for relocation		100
	Subtotal	8,600
Additional land for recreation (others)		1,100
Additional land for recreation (CE)		800
	Total	10,500

g. Cost estimate. The cost estimates are summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-12
Cost estimate of Irondale Reservoir (9)

Item	Cost
Lands and damages	$ 1,910,000
Relocations	3,570,000
Reservoir clearing	219,000
Dams and appurtenant works	4,678,000
Fish and wildlife facilities	10,000
Access road	342,000
Recreation facilities	480,000
Buildings, grounds, and utilities	217,000
Permanent operating equipment	153,000
Engineering and design	1,130,000
Supervision and administration	791,000
Total	$13,500,000

22. VIRGINIA MINES RESERVOIR (40) (PLATES E-8 and E-9)

a. Location. This reservoir is the lowermost reservoir on the Meramec River with the dam located at mile 82.5. There is a drainage area of 240 square miles between the site and Meramec Park Dam upstream.

b. Design details.

(1) The proposed rolled-earth embankment will have a crest length of about 2,190 feet and rise approximately 92 feet high. The crown width at crest elevation of 592 feet would be 35 feet. The upstream slope of the embankment will be 1 on 3. The downstream slope will be 1 on 2 down to elevation 562 and 1 on 2.5 down to the valley floor. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 527.

(2) The chute spillway will be of reinforced concrete founded on rock in the left abutment. It will consist of entrance bay, overflow section with crest at elevation 556, chute on a slope of 1 on 20 at upper end and 1 on 6.67 at lower end, and stilling basin with floor at elevation 490. The spillway will be 200 feet wide at the crest and in the chute, flaring to 300 feet in the stilling basin. A highway bridge will span the spillway with low steel at elevation 592, the top of the dam.

(3) The outlet works with invert at river bottom elevation will be founded on rock in the right of the valley. They will consist of a quadruple 6'-9" x 12'-0" concrete cut-and-cover conduit, a stilling basin, and gate structure complete with service and emergency tractor gates for flood control releases. Three 54" x 54" power-operated water quality control gates will be placed between the top of the joint-use pool and the conduit. The gate structure will be surmounted by an operating house with access from the dam by a service bridge.

(4) All the tractor gates will be operated by one hoist, rail-mounted in the upper level of the gate structure. The hoist will consist of a hand-operated bridge and trolley and an electrically powered hoist. The hoist will have a capacity of 52 tons and a lift of 92 feet.

c. Electrical features. The gate hoist electrical equipment will consist of the following items: a high-torque, high slip, squirrel cage induction motor; a motor-operated shoe brake; and control equipment consisting of controller, limit switch, and control station. The motors will be equipped with winding heaters. Control equipment inclosures will be of watertight, dust tight, and moisture-resisting construction. The gate-operating house will be electrically lighted to an average illumination of 10 foot-candles. A lightning protection system will be provided for the gate hoist structure.

d. Borings. Boring locations and estimated depth to rock are shown on PLATE E-9. Logs of borings are shown on sections presented on PLATE D-9. No indications of major adverse foundation factors have been disclosed.

e. Relocations and alterations.

(1) Roads. The reservoir would necessitate building about 3.5 miles of new road and improving 2.2 miles of existing road. Cost estimates for the individual relocations, as shown in the table below, may be found in APPENDIX T.

TABLE E-13
Road alterations at Virginia Mines Reservoir (40)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
S-1	-	1.5	Relocate Route K across reservoir west of present location.
C-1	0.5	0.5	County road to maintain connection between road nets east and west of Indian Creek.
C-2	-	0.7	County road to maintain north-south service at southern end of reservoir.
A-1	-	0.8	Road across dam.
A-2	1.7	-	Raise road into Meramec Caverns.

(2) Pipelines. There are no pipeline crossings of Virginia Mines Reservoir which will require alteration or relocation.

(3) Power and telephone lines. Approximately 30 miles of power distribution lines and 18 miles of telephone lines will require alteration due to construction of this reservoir.

(4) Cemeteries. A total of 60 graves was found by field reconnaissance. It is planned to relocate existing graves and headstones in all cemeteries within the pool to higher ground.

f. Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-14
Land requirements of Virginia Mines Reservoir (40)

Reservoir operation and construction	Acres
Below maximum pool	
Cleared land	2,400
Timberland	2,300
Existing streams	500

TABLE E-14 (Cont'd)

Reservoir operation and construction		Acres
Above maximum pool (300' strip)		7,900
Dam and working areas		300
Rights-of-way for relocations		70
	Subtotal	13,470
Additional land for recreation (others)		3,600
Additional land for recreation (CE)		1,500
	Total	18,570

g. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-15
Cost estimate of Virginia Mines Reservoir (40)

Item	Cost
Lands and damages	$ 3,915,000
Relocations	3,219,000
Reservoir clearing	492,000
Dam and appurtenant works	6,590,000
Fish and wildlife facilities	10,000
Access road	407,000
Recreation facilities	1,000,000
Buildings, grounds, and utilities	217,000
Permanent operating equipment	149,000
Engineering and design	1,410,000
Supervision and administration	991,000
Total	$18,400,000

23. MERAMEC PARK RESERVOIR (17) (PLATES E-10 and E-11)

a. Location. This reservoir, with dam located at mile 107.5, is the largest in the system. The total drainage above the damsite is 1,508 square miles.

b. Design details.

(1) The proposed rolled-earth embankment will have a crest length of about 2,550 feet and rise approximately 170 feet high. The crown width at crest elevation of 736 feet will be 35 feet. The upstream slope of the embankment will be 1 on 2 down to elevation 727, 1 on 2.5

down to elevation 680, 1 on 3 down to elevation 640, and 1 on 3.5 down to the valley floor. The downstream slope will be 1 on 2 down to elevation 727, 1 on 2.25 down to elevation 680, 1 on 2.5 down to elevation 640, and 1 on 2.75 down to the valley floor. Internal drainage for the embankment will be provided by a filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 600.

(2) The chute spillway will be of reinforced concrete founded on rock in the left abutment. It will consist of entrance bay, overflow sections with crest elevation at 701, chute on a 1 on 4 slope, and stilling basin with floor at elevation 544. The spillway will be 200 feet wide at the crest converging to 150 feet in the chute and stilling basin for economy in cost. A highway bridge will span the spillway with low steel at elevation 736, the top of the dam.

(3) The outlet works with invert at river bottom elevation will be founded on rock in the center of the valley. They will consist of a triple 6'-9" x 12'-0" concrete cut-and-cover conduit, a stilling basin, and gate structure complete with service and emergency tractor gates for flood control releases. Three 54" x 54" power-operated water quality control gates will be placed between the top of the joint-use pool and the conduit. The gate structure will be surmounted by an operating house with access from the dam by a service bridge.

(4) All the tractor gates will be operated by one hoist, rail-mounted in the upper level of the gate structure. The hoist will consist of a hand-operated bridge and trolley and an electrically powered hoist. The hoist will have a capacity of 88 tons and a lift of 170 feet.

c. Electrical features. The gate hoist electrical equipment will consist of the following items: a high-torque, high slip, squirrel cage induction motor; a motor-operated shoe brake; and control equipment, consisting of controller, limit switch, and control station. The motors will be equipped with winding heaters. Control equipment inclosures will be of watertight, dust tight, and moisture-resisting construction. The gate-operating house will be electrically lighted to an average illumination of 10 foot-candles. A lightning protection system will be provided for the gate hoist structure.

d. Borings. Locations of selected borings from previous studies are presented on PLATES D-10 and E-12. Logs of borings are shown on PLATES D-11 and D-12. The existence of permeable strata, caves, and sinks adjacent to the axis will require additional exploration during the planning stage and adequate sealing during construction.

e. Relocations and alterations.

(1) Roads. The reservoir would necessitate building about 18.5 miles of new road and improving 4.5 miles of existing road. Cost estimates for the individual relocations as shown in the following table may be found in APPENDIX T.

TABLE E-16
Road alterations at Meramec Park Reservoir (17)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
S-1	-	9.1	Relocate Route N north of present location.
S-2	0.6	-	Raise Route 8 across reservoir.
S-3	0.5	-	Raise Route D to maintain access south of State Creek.
C-1	-	0.7	Provide new county road crossing of the reservoir in upper end.
C-2	-	0.7	Maintain access to area south of Hyde Branch.
C-3	-	3.5	Provide access to isolated area east of reservoir.
C-4	1.2	-	Maintain county road crossing at Bird's Nest.
C-5	1.3	-	Maintain service to Doss Branch area from Route 8.
C-6	0.4	0.4	Maintain service between Hinch, Missouri, and old Route N.
C-7	0.5	-	Maintain service between Bass Branch area and Hinch, Missouri.
C-8	-	1.9	Connect road nets north and south of Brazil Creek.
C-9	-	1.9	Connect road nets north and south of Brazil Creek.
A-1	-	0.3	Road across dam.

(2) Pipelines. There are two 10-inch parallel oil lines owned by the Gulf Refining Company which would be inundated by the reservoir. To maintain present service, 2,550 feet of dual line across Courtois Creek and 1,500 feet of dual line across Huzzah Creek would require alteration.

(3) Power and telephone lines. Approximately 100 miles of power distribution lines and 70 miles of telephone lines will require alteration due to construction of this reservoir.

(4) Cemeteries. Field investigation located 350 graves within the reservoir area. It is planned to relocate existing graves and headstones in all cemeteries within the pool to higher ground.

f. Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-17
Land requirements of Meramec Park Reservoir (17)

Reservoir operation and construction		Acres
Below maximum flood pool		
Cleared land		12,500
Timberland		13,100
Existing streams		1,900
Above maximum flood pool (300' strip)		11,400
Dam and working areas		400
Rights-of-way for relocations		200
	Subtotal	39,500
Additional land for recreation (others)		5,200
Additional land for recreation (CE)		3,700
Replacement of wildlife habitat		500
	Total	48,900

g. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-18
Cost estimate of Meramec Park Reservoir (17)

Item	Cost
Lands and damages	$10,918,000
Relocations	6,885,000
Reservoir clearing	1,206,000
Dam and appurtenant works	10,795,000
Fish and wildlife facilities	10,000

TABLE 18 (Cont'd)

Item	Cost
Access road	$ 163,000
Recreation facilities	3,150,000
Buildings, grounds, and utilities	229,000
Permanent operating equipment	194,000
Engineering and design	2,240,000
Supervision and administration	1,910,000
Total	$37,700,000

24. SALEM RESERVOIR (27) (PLATES E-13 and E-14)

a. Location. This reservoir, with dam located at mile 190.6, Meramec River, is the uppermost major reservoir in the system. The total drainage area above the site is 175 square miles.

b. Design details.

(1) The proposed rolled-earth embankment will have a crest length of about 2,090 feet and rise approximately 150 feet above the valley floor. The crown width at crest elevation of 1,039 feet will be 35 feet. The upstream slope of the embankment will be 1 on 3 down to elevation 1,008 and 1 on 4 down to the valley floor; the downstream slope will be 1 on 3. Internal drainage for the embankment will be provided by a chimney drain and filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 928.

(2) The chute spillway will be of reinforced concrete founded on rock on the left abutment. It will consist of entrance bay, overflow section with crest at elevation 1,008, chute on a 1 on 4 slope, and stilling basin with floor at elevation 874. The spillway will be 200 feet wide at the crest, converging to 150 feet in the chute and stilling basin for economy of cost.

(3) The outlet works with invert at river bottom elevation will be founded on rock in the right of the valley. They will consist of a 5'-3" x 6'-6" concrete cut-and-cover conduit, a stilling basin, and gate structure complete with service and emergency tractor gates for flood control releases. Three 54" x 54" power-operated water quality control gates will be placed between the top of the joint-use pool and the conduit. The gate structure will be surmounted by an operating house with access from the dam by a service bridge.

(4) All the tractor gates will be operated by one hoist, rail-mounted in the upper level of the gate structure. The hoist will consist of a hand-operated bridge and trolley and an electrically powered hoist. The hoist will have a capacity of 42 tons and a lift of 145 feet.

c. Electrical features. The gate hoist electrical equipment will consist of the following items: a high-torque, high slip, squirrel cage induction motor; a motor-operated shoe brake; and control equipment, consisting of controller, limit switch, and control station. The motors will be equipped with winding heaters. Control equipment inclosures will be of watertight, dust tight, and moisture-resisting construction. The gate-operating house will be electrically lighted to an average illumination of 10 foot-candles. A lightning protection system will be provided for the gate hoist structure.

d. Borings. Locations of borings and estimated depth to firm rock are shown on PLATE E-14. Boring logs may be found on PLATE D-13. There are major foundation defects at this site, consisting of deep weathering on the right abutment and existence of caves in the left abutment, which would require additional exploration during the planning stage and adequate sealing during construction.

e. Relocations and alterations.

(1) Roads. The reservoir would necessitate building about 6.8 miles of new road. Cost estimates for the individual relocations, as shown in the table below, may be found in APPENDIX T.

TABLE E-19
Road alterations at Salem Reservoir (27)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
S-1	-	3.3	Relocate Route 19 across reservoir.
A-1	-	3.5	Road to dam.

(2) Pipelines. There are no pipeline crossings of Salem Reservoir which require relocation or alteration.

(3) Power and telephone lines. Approximately 12 miles of power distribution lines, 0.5 mile of 69 KV power transmission lines, and 10 miles of telephone lines will require alteration due to construction of this reservoir.

(4) Cemeteries. A total of 120 graves was found by field reconnaissance. It is planned to relocate existing graves and headstones in all cemeteries within the pool to higher ground.

f. Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-20
Land requirements of Salem Reservoir (27)

Reservoir operation and construction		Acres
Below maximum flood pool		
Cleared land		1,700
Timberland		2,100
Existing streams		300
Above maximum flood pool (300' strip)		2,400
Dam and working areas		400
Rights-of-way for relocations		80
	Subtotal	6,980
Additional land for recreation (others)		1,900
Additional land for recreation (CE)		700
	Total	9,580

g. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-21
Cost estimate of Salem Reservoir (27)

Item	Cost
Lands and damages	$ 1,300,000
Relocations	2,070,000
Reservoir clearing	177,000
Dam and appurtenant works	7,871,000
Fish and wildlife facilities	10,000
Access road	313,000
Recreation facilities	460,000
Buildings, grounds, and utilities	217,000
Permanent operating equipment	157,000
Engineering and design	1,330,000
Supervision and administration	995,000
Total	$14,900,000

25. UNION RESERVOIR (29) (PLATES E-15 and E-16)

a. Location. This reservoir, with the dam located at mile 31.6 on the Bourbeuse River, is the only major dam on that tributary. The total drainage area above the damsite is 754 square miles.

b. Design details.

(1) The proposed rolled-earth embankment will have a crest length of about 3,720 feet and rise approximately 140 feet above the valley floor. The crown width at crest elevation of 682 feet will be 35 feet. The upstream slope of the embankment will be 1 on 2 down to elevation 674, 1 on 2.5 down to elevation 638, 1 on 3 down to elevation 598, and 1 on 3.5 down to the valley floor. The downstream slope will be 1 on 2 down to elevation 674, 1 on 2.25 down to elevation 638, 1 on 2.5 down to elevation 598, and 1 on 2.75 down to the valley floor. Internal drainage for the embankment will be provided by a filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 567.

(2) The chute spillway will be of reinforced concrete founded on rock on the left abutment. It will consist of entrance bay, overflow section with crest at elevation 651, chute on a 1 on 4 slope, and a stilling basin with floor at elevation 526. The spillway will be 200 feet wide at the crest, converging to 150 feet in the chute and stilling basin for economy in cost. A highway bridge will span the spillway with low steel at elevation 682, the top of dam.

(3) The outlet works with invert at river bottom elevation will be founded on rock in the right of the valley. They will consist of a double 6'-0" x 11'-0" concrete cut-and-cover conduit, stilling basin, and gate structure complete with service and emergency tractor gates for flood control releases. Three 54" x 54" power-operated water quality control gates will be placed between the top of the joint-use pool and the conduit. The gate structure will be surmounted by an operating house with access from the dam by a service bridge.

(4) All the tractor gates will be operated by one hoist, rail-mounted in the upper level of the gate structure. The hoist will consist of a hand-operated bridge and trolley and an electrically powered hoist. The hoist will have a capacity of 70 tons and a lift of 151 feet.

c. Electrical features. The gate hoist electrical equipment will consist of the following items: a high-torque, high slip squirrel cage induction motor; a motor-operated shoe brake; and control equipment consisting of controller, limit switch, and control station. The motors

will be equipped with winding heaters. Control equipment inclosures will be of watertight, dust tight, and moisture-resisting construction. The gate-operating house will be electrically lighted to an average illumination of 10 foot-candles. A lightning protection system will be provided for the gate hoist structure.

d. Borings. Location of selected borings from previous studies appears on PLATES D-14 and E-17; logs of borings are shown on PLATES D-15 and D-16. There are no indications of foundation defects at this site.

e. Relocations and alterations.

(1) Roads. The reservoir would necessitate building 6.1 miles of new road and improving 3.1 miles of existing road. Cost estimates for the individual relocations as shown in the following table may be found in APPENDIX T.

TABLE E-22
Road alterations at Union Reservoir (29)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
S-1	-	0.7	Relocate Route 155 across reservoir.
S-2	0.2	-	Raise Route CC across reservoir arm.
S-3	0.5	-	Raise Route CC across reservoir.
S-4	1.8	-	State road to maintain connection between road nets east and west of Boone Creek.
C-1	-	3.0	Maintain access to area south of Voss Creek.
C-2	-	1.2	Maintain access to area south of Noser Mill, Missouri.
C-3	0.6	0.7	Maintain connection between road nets north and south of Spring Creek.
A-1	-	0.5	Road across dam.

(2) Pipelines. There are no pipeline crossings of Union Reservoir which require alteration or relocation.

(3) Power and telephone lines. Approximately 80 miles of power distribution lines, 0.5 mile of 69 KV power transmission lines, and 50 miles of telephone lines will require alteration due to construction of this reservoir.

(4) Cemeteries. A total of 100 graves was found by field reconnaissance. It is planned to relocate existing graves and headstones in all cemeteries within the pool to higher ground.

f. Land requirements. The estimated land requirements are summarized in the following table:

TABLE E-23
Land requirements of Union Reservoir (29)

Reservoir operation and construction		Acres
Below maximum flood pool		
Cleared land		8,400
Timberland		7,100
Existing streams		1,100
Above maximum flood pool (300' strip)		8,200
Dam and working areas		400
Rights-of-way for relocations		130
	Subtotal	25,330
Additional land for recreation (others)		1,600
Additional land for recreation (CE)		1,900
	Total	28,830

g. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-24
Cost estimate of Union Reservoir (29)

Item		Cost
Lands and damages		$ 6,577,000
Relocations		4,394,000
Reservoir clearing		750,000
Dam and appurtenant works		9,395,000
Fish and wildlife facilities		10,000
Access road		341,000
Recreation facilities		750,000
Buildings, grounds, and utilities		217,000
Permanent operating equipment		176,000
Engineering and design		1,740,000
Supervision and administration		1,250,000
	Total	$25,600,000

SECTION III - DESCRIPTION OF TRIBUTARY RESERVOIRS

26. GENERAL

TABLE E-25 gives pertinent data on the 12 tributary reservoirs retained for economic analysis. TABLE E-26 summarizes land requirements.

27. BIG RIVER SUB-BASIN

a. Terre Bleue Creek Reservoir (I-30) (PLATES E-18 and E-19)

(1) Location. This reservoir is the only tributary reservoir in the Big River system. The dam is located at mile 11.6 on Terre Bleue Creek. The total drainage area above the damsite is 19.8 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 1,745 feet and rise approximately 60 feet above the valley floor. The crown width at crest elevation 811 will be 30 feet. The upstream slope of the embankment will be 1 on 2.5 down to elevation 791 and 1 on 3 down to the valley floor. The downstream slope will be 1 on 2.5. Internal drainage for the embankment will be provided by a chimney drain and filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 771.

(b) The chute spillway will be of reinforced concrete and will be located in the right abutment. It will consist of entrance bay, overflow section with crest at elevation 790, chute on a 1 on 13 slope, and stilling basin with floor at elevation 740. The spillway will be 50 feet wide throughout its length. The overflow section and chute will be founded on earth, with the stilling basin founded on rock.

(c) The outlet works with invert at river bottom will be founded on rock in the center of the valley. They will consist of a 4'-3" x 5'-3" concrete cut-and-cover conduit, stilling basin, and a gate structure complete with sluice gate for flood control releases. Two 30" x 30" water quality control gates will be placed between the top of the joint-use pool and the conduit.

(d) Gates will be manually operated with provision for portable power. Access to the top of the gate structure will be by foot bridge.

TABLE E-25
Tributary reservoir data sheet

	I-30	I-15A	I-14	I-26	I-41	I-23	I-28	I-32	I-33A	I-35A	I-21	I-38
Top dam elevation (m.s.l.)	811	867	916	1,046	898	965	1,124	728	797	809	916	880
Spillway crest elevation (m.s.l.)	790	834	881	1,026	874	941	1,112	718	777	786	904	857
Normal pool elevation (m.s.l.)	782	806	847	1,019	853	941	1,101	718	777	786	887	837
Minimum conservation pool elevation (m.s.l.) (100-year sediment capacity)	771	799	837	959	850	914	1,079	689	743	756	885	830
River bottom elevation (m.s.l.)	745	765	805	925	825	885	1,045	665	705	735	865	805
Drainage area (sq. mi.)	19.8	122	112	27	28.8	36	44	60	52	69	23.5	121
Storage (ac.-ft.)												
Total	7,100	38,000	35,400	26,000	10,300	12,700	26,000	26,000	26,000	26,000	8,600	39,000
Flood control	2,700	29,600	27,500	4,600	7,700	-	11,800	-	-	-	6,300	29,600
Joint-use	4,400	8,400	7,900	21,400	2,600	12,700	14,200	26,000	26,000	26,000	2,300	9,400
Sediment	1,500	4,800	4,000	1,800	1,900	2,100	2,500	3,000	2,700	3,300	1,600	4,700
Net joint-use	2,900	3,600	3,900	19,600	700	10,600	11,700	23,000	23,300	22,700	700	4,700
Pool areas (acres)												
Maximum spillway surcharge	1,150	2,700	2,100	1,200	800	1,200	2,100	2,250	1,900	2,100	1,000	5,500
Flood control pool	950	1,600	1,250	950	450	-	1,750	-	-	-	800	2,950
Normal pool	270	620	460	630	230	950	900	2,050	1,450	1,400	220	850
Minimum conservation pool	170	440	310	120	200	200	200	550	230	250	170	450
Dam dimensions												
Crest length (feet)	1,745	2,170	1,655	1,300	1,770	3,050	1,465	2,205	2,700	2,400	2,275	3,000
Base width (feet)	376	581	631	686	422	540	534	430	618	566	352	508
Volume (cubic yards)	365,000	1,080,000	963,000	981,000	412,000	846,000	339,000	654,000	1,002,000	862,000	417,000	769,000
Spillway												
Type	Chute	Chute	Chute	Chute	Chute	Chute	Earth	Earth	Chute	Chute	Earth	Chute
Length (feet)	50	50	50	50	50	50	625	1,100	50	50	365	50
Capacity (c.f.s.)	12,280	30,410	33,900	11,080	16,280	16,280	34,730	36,890	11,080	14,890	20,280	14,890
Maximum surcharge (feet)	16	28	30	15	19	19	7	5	15	18	7	18
Outlets*												
Size	4'3"x5'3"	8'0"x10'0"	8'0"x10'0"	4'9"x6'0"	4'9"x6'0"	5'3"x6'6"	5'6"x7'6"	6'3"x7'9"	5'6"x7'6"	6'6"x8'0"	4'9"x6'0"	8'0"x10'0"
Maximum controlled discharge (c.f.s.)	100	610	560	135	144	178	220	300	260	345	118	605
Minimum controlled discharge (c.f.s.)	7	18	18	13	4	14	10	20	19	22	1	12

*Outlets, controlled by tractor gates, are sized for diversion and have capacities exceeding bankfull capacity.

TABLE E-26
Tributary reservoirs
Land requirements
(acres)

Reservoir	Land required up to top pool elevation	Access land reqd. from top pool elev. back 300' horiz. plus dam spillway and borrow areas	Land required for initial CE rec. dev.	Land required to replace State lands inundated	Land required for land-based rec. in Clark Nat. Forest	Land required for relocations	Land required for future rec. dev. and for mitigation of wildlife habitat losses	Total land requirements
I-30	950	650	100	-	-	5	400	2,105
I-15A	1,600	950	100	-	1,200	50	600	4,500
I-14	1,250	900	200	-	1,400	15	1,900	5,665
I-26	950	650	100	-	-	30	-	1,730
I-41	450	450	100	-	-	30	300	1,330
I-23	950	750	100	-	-	-	1,100	2,900
I-28	1,750	1,150	300	-	-	20	1,300	4,520
I-32	2,050	1,250	200	-	-	5	400	3,905
I-33A	1,450	1,050	200	-	-	10	800	3,510
I-35A	1,400	1,000	200	-	-	30	900	3,530
I-21	800	700	100	-	-	10	300	1,910
I-38	2,950	1,750	300	-	-	25	1,000	6,025
Total for tributary reservoirs	16,550	11,250	2,000	-	2,600	230	9,000	41,630

(3) Relocations and alterations.

(a) Roads. The reservoir necessitates building about 0.1 mile of new road and improving 0.6 mile of existing road. Cost estimates for the individual relocations shown in the following table may be found in APPENDIX T.

TABLE E-27
Road alterations at Terre Bleue Creek Reservoir (I-30)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
S-1	0.6	-	Raise Route JJ across reservoir.
A-1	-	0.1	Road across dam.

(b) Pipelines. There are no pipeline crossings.

(c) Power and telephone lines. Approximately 4 miles of power distribution lines and 3 miles of telephone lines will require alteration due to construction of this reservoir.

(d) Cemeteries. There were no cemeteries found by field reconnaissance. However, a liberal allowance for cemetery relocation is included in the cost estimate.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-28
Land requirements of Terre Bleue Creek Reservoir (I-30)

Reservoir operation and construction	Acres
Below maximum flood pool	
Cleared land	390
Timberland	470
Existing streams	90
Above maximum flood pool (300' strip)	450
Dam and working areas	200
Rights-of-way for relocations	5
Subtotal	1,605

TABLE E-28 (Cont'd)

Reservoir operation and construction	Acres
Additional land for recreation (others)	400
Additional land for recreation (CE)	100
Total	2,105

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-29
Cost estimate of Terre Bleue Creek Reservoir (I-30)

Item	Cost
Lands and damages	$ 285,000
Relocations	336,000
Reservoir clearing	23,000
Dam and appurtenant works	1,628,000
Fish and wildlife facilities	3,000
Access road	110,000
Recreation facilities	100,000
Buildings, grounds, and utilities	182,000
Permanent operating equipment	82,000
Engineering and design	523,000
Supervision and administration	268,000
Total	$3,540,000

28. MERAMEC RIVER SUB-BASIN (ABOVE MOUTH BOURBEUSE RIVER)

a. Courtois Creek Reservoir (I-15A) (PLATES E-20 and E-21)

(1) Location. This reservoir is located on Courtois Creek, with the dam 18.8 miles above its confluence with the Huzzah Creek, which joins the Meramec at mile 130.5.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 2,170 feet and rise approximately 90 feet above the valley floor. The crown width at crest elevation 867 will be 30 feet. The upstream slope of the embankment will be 1 on 2.5 down to elevation 847 and 1 on 3 down to the valley floor. The downstream slope will be 1 on 2.5. Internal drainage for the embankment will be

provided by a chimney drain and filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 799.

(b) The chute spillway will be of reinforced concrete founded on the left abutment. It will consist of entrance bay, overflow section with crest at elevation 834, chute on a 1 on 13 slope, and stilling basin with floor at elevation 747. The spillway will be 50 feet wide at the crest and chute flaring to 70 feet in the stilling basin. The overflow section and upper part of the chute will be founded on earth, with the lower part of the chute and the stilling basin founded on rock.

(c) The outlet works with invert at river bottom will be founded on rock in the center of the valley. They will consist of a 8'-0" x 10'-0" concrete cut-and-cover conduit, stilling basin, and a gate structure complete with sluice gate for flood control releases. Two 30" x 30" water quality control gates will be placed between the top of the joint-use pool and the conduit.

(d) Gates will be manually operated with provision for portable power. Access to the top of the gate structure will be by foot bridge.

(3) Relocations and alterations.

(a) Roads. The reservoir necessitates building 5.3 miles of new road. A cost estimate for the relocations shown below may be found in APPENDIX T.

TABLE E-30
Road alterations at Courtois Creek Reservoir (I-15A)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
A-1	-	5.3	Road across dam.

(b) Pipelines. There are no pipeline crossings.

(c) Power and telephone lines. Approximately 1 mile of power distribution lines and 1 mile of telephone lines will require alteration due to construction of this reservoir.

(d) Cemeteries. There were no cemeteries found by field reconnaissance. However, a liberal allowance for cemetery relocation cost is included in the cost estimate.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-31
Land requirements of Courtois Creek Reservoir (I-15A)

Reservoir operation and construction		Acres
Below maximum flood pool		
Cleared land		400
Timberland		1,160
Existing streams		40
Above maximum flood pool (300' strip)		750
Dam and working areas		200
Rights-of-way for relocations		50
	Subtotal	2,600
Additional land for recreation (others)		1,200
Additional land for recreation (CE)		100
Replacement of wildlife habitat		600
	Total	4,500

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-32
Cost estimate of Courtois Creek Reservoir (I-15A)

Item	Cost
Lands and damages	$ 545,000
Relocations	430,000
Reservoir clearing	46,000
Dam and appurtenant works	3,556,000
Fish and wildlife facilities	3,000
Access road	787,000
Recreation facilities	100,000
Buildings, grounds, and utilities	182,000
Permanent operating equipment	74,000
Engineering and design	761,000
Supervision and administration	466,000
Total	$6,950,000

b. Huzzah Creek Reservoir (I-14) (PLATES E-22 and E-23)

(1) Location. This reservoir is located on Huzzah Creek, with dam 24.7 miles above its confluence with the Meramec River. The total drainage area above the damsite is 112 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 1,655 feet and rise approximately 100 feet above the valley floor. The crown width at crest elevation 916 will be 30 feet. The upstream slope of the embankment will be 1 on 2.5 down to elevation 896 and 1 on 3 down to the valley floor. The downstream slope will be 1 on 2.5. Internal drainage for the embankment will be provided by a chimney drain and filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 837.

(b) The chute spillway will be of reinforced concrete founded on the left abutment. It will consist of entrance bay, overflow section with crest at elevation 881, chute on a 1 on 8 slope, and stilling basin with floor at elevation 775. The spillway will be 50 feet wide at the crest and chute flaring to 70 feet in the stilling basin. The overflow section and upper part of the chute will be founded on earth, with the lower part of the chute and the stilling basin founded on rock.

(c) The outlet works with invert at river bottom will be founded on rock in the right of the valley. They will consist of an 8'-0" x 10'-0" concrete cut-and-cover conduit, stilling basin, and a gate structure complete with sluice gate for flood control releases. Two 30" x 30" water quality control gates will be placed between the top of the joint-use pool and the conduit.

(d) Gates will be manually operated with provision for portable power. Access to the top of the gate structure will be by foot bridge.

(3) Relocations and alterations.

(a) Roads. The reservoir necessitates building 0.9 mile of new road. Cost estimates for the relocations shown below may be found in APPENDIX T.

TABLE E-33
Road alteration at Huzzah Creek Reservoir (I-14)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
A-1	-	0.9	Road across dam

(b) Pipelines. There are no pipeline crossings.

(c) Power and telephone lines. There are no power and telephone lines.

(d) Cemeteries. There were no cemeteries found by field reconnaissance. However, a liberal allowance for cemetery relocation is included in the cost estimate.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-34
Land requirements of Huzzah Creek Reservoir (I-14)

Reservoir operation and construction	Acres
Below maximum flood pool	
Cleared land	250
Timberland	980
Existing streams	20
Above maximum flood pool (300' strip)	650
Dam and working areas	250
Rights-of-way for relocations	15
Subtotal	2,165
Additional land for recreation (others)	1,400
Additional land for recreation (CE)	200
Replacement of wildlife habitat	1,900
Total	5,665

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-35
Cost estimate of Huzzah Creek Reservoir (I-14)

Item	Cost
Lands and damages	$1,130,000
Relocations	153,000
Reservoir clearing	49,000
Dam and appurtenant works	3,483,000
Fish and wildlife facilities	3,000
Access road	444,000

TABLE E-35 (Cont'd)

Item	Cost
Recreation facilities	$ 50,000
Buildings, grounds, and utilities	181,000
Permanent operating equipment	75,000
Engineering and design	655,000
Supervision and administration	417,000
Total	$6,640,000

c. West Fork Huzzah Creek Reservoir (I-26) (PLATES E-24 and E-25)

(1) Location. This reservoir is located on the west fork of Huzzah Creek, with dam 0.5 mile above its junction with the east fork at mile 35.0. The total drainage area above the damsite is 27 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 1,300 feet and rise approximately 115 feet above the valley floor. The crown width at crest elevation 1,046 will be 30 feet. The upstream slope of the embankment will be 1 on 2.5 down to elevation 1,026 and 1 on 3 down to the valley floor. The downstream slope will be 1 on 2.5. Internal drainage for the embankment will be provided by a chimney drain and filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 959.

(b) The chute spillway will be of reinforced concrete founded on the left abutment. It will consist of entrance bay, overflow section with crest at elevation 1,026, chute on a 1 on 7 slope, and a stilling basin with floor at elevation 913. The spillway will be 50 feet wide throughout its length. The overflow section and upper part of the chute will be founded on earth, with the lower part of the chute and the stilling basin founded on rock.

(c) The outlet works with invert at river bottom will be founded on rock in the right abutment of the valley. They will consist of a 4'-9" x 6'-0" concrete cut-and-cover conduit, stilling basin, and a gate structure complete with sluice gate for flood control releases. Two 30" x 30" water quality control gates will be placed between the top of the joint-use pool and the conduit.

(d) Gates will be manually operated with provision for portable power. Access to the top of the gate structure will be by foot bridge.

(3) Relocations and alterations.

(a) Roads. The reservoir necessitates building 3.0 miles of new road. Cost estimates for the individual relocations shown below may be found in APPENDIX T.

TABLE E-36
Road alterations at West Fork Huzzah Creek Reservoir (I-26)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
C-1	-	2.1	County road to maintain north-south service.
A-1	-	0.9	Road across dam.

(b) Pipelines. There are no pipeline crossings.

(c) Power and telephone lines. Approximately 4 miles of power distribution lines and 3 miles of telephone lines will require alteration due to construction of this reservoir.

(d) Cemeteries. Field reconnaissance determined that 75 graves in the reservoir area would have to be relocated to higher ground.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-37
Land requirements of West Fork Huzzah Creek Reservoir (I-26)

Reservoir operation and construction	Acres
Below maximum flood pool	
Cleared land	370
Timberland	490
Existing streams	90
Above maximum flood pool (300' strip)	450
Dam and working areas	200
Rights-of-way for relocations	30
Subtotal	1,630

TABLE E-37 (Cont'd)

Reservoir operation and construction	Acres
Additional land for recreation (CE)	100
Total	1,730

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-38
Cost estimate of West Fork Huzzah Creek Reservoir (I-26)

Item	Cost
Lands and damages	$ 247,000
Relocations	320,000
Reservoir clearing	32,000
Dam and appurtenant works	2,308,000
Fish and wildlife facilities	3,000
Access road	160,000
Recreation facilities	50,000
Buildings, grounds, and utilities	182,000
Permanent operating equipment	74,000
Engineering and design	578,000
Supervision and administration	326,000
Total	$4,280,000

d. Benton Creek Reservoir (I-41) (PLATES E-26 and E-27)

(1) Location. This reservoir is located on Benton Creek, a Meramec River tributary which enters the Meramec at mile 175.7. The dam is 0.9 mile above the confluence. The total drainage area above the damsite is 28.8 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 1,770 feet and rise approximately 70 feet above the valley floor. The crown width at crest elevation 898 will be 30 feet. The upstream slope of the embankment will be 1 on 2.5 down to elevation 878 and 1 on 3 down to the valley floor. The downstream slope will be 1 on 2.5. Internal drainage for the embankment will be provided by a chimney drain and filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to

determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 850.

(b) The chute spillway will be of reinforced concrete founded on the left abutment. It will consist of entrance bay, overflow section with crest at elevation 874, chute on a 1 on 10 slope, and stilling basin with floor at elevation 820. The spillway will be 50 feet wide throughout its length. The overflow section and the upper part of the chute will be founded on earth, with the lower part of the chute and the stilling basin founded on rock.

(c) The outlet works with invert at river bottom will be founded on rock in the center of the valley. They will consist of a 4'-9" x 6'-0" concrete cut-and-cover conduit, stilling basin, and a gate structure complete with sluice gate for flood control releases. Two 30" x 30" water quality control gates will be placed between the top of the joint-use pool and the conduit.

(d) Gates will be manually operated with provision for portable power. Access to the top of the gate structure will be by foot bridge.

(3) Relocations and alterations.

(a) Roads. The reservoir necessitates building 2.9 miles of new road. Cost estimates for the individual relocations shown below may be found in APPENDIX T.

TABLE E-39
Road alterations at Benton Creek Reservoir (I-41)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
C-1	-	1.1	County road to maintain east-west service across Benton Creek.
C-2	-	0.4	County road to maintain road net west of the reservoir.
A-1	-	1.4	Road across dam.

(b) Pipelines. There are two 10-inch parallel oil lines owned by the Gulf Refining Company which would be inundated by

reservoir I-41; 2,450 feet of this dual line will require alteration to maintain present service.

(c) Power and telephone lines. Approximately 2 miles of power distribution lines and 2 miles of telephone lines will require alteration due to construction of this reservoir.

(d) Cemeteries. There were no cemeteries found by field reconnaissance. However, a liberal allowance for cemetery relocation cost is included in the cost estimate.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-40
Land requirements of Benton Creek Reservoir (I-41)

Reservoir operation and construction	Acres
Below maximum flood pool	
Cleared land	240
Timberland	180
Existing streams	30
Above maximum flood pool (300' strip)	250
Dam and working areas	200
Rights-of-way for relocations	30
Subtotal	930
Additional land for recreation (others)	300
Additional land for recreation (CE)	100
Total	1,330

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-41
Cost estimate of Benton Creek Reservoir (I-41)

Item	Cost
Lands and damages	$ 167,000
Relocations	513,000
Reservoir clearing	16,000
Dam and appurtenant works	1,558,000
Fish and wildlife facilities	3,000

TABLE E-41 (Cont'd)

Item	Cost
Access road	$ 254,000
Recreation facilities	50,000
Buildings, grounds, and utilities	182,000
Permanent operating equipment	81,000
Engineering and design	566,000
Supervision and administration	290,000
Total	$3,680,000

e. Little Dry Fork Creek Reservoir (I-23) (PLATES E-28 and E-29)

(1) Location. This dam is located at mile 2.3 on Little Dry Fork Creek, a tributary of Dry Fork, which it enters 18.0 miles above the confluence of Dry Fork with the Meramec at mile 167.8. The total drainage area above the damsite is 36 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 3,050 feet and rise approximately 65 feet above the valley floor. The crown width at crest elevation 965 will be 30 feet. The upstream slope of the embankment will be 1 on 3 down to elevation 945 and 1 on 3.5 down to the valley floor. The downstream slope will be 1 on 3. Internal drainage for the embankment will be provided by a chimney drain and filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of revetment down to elevation 914.

(b) The chute spillway will be of reinforced concrete founded on the left abutment. It will consist of entrance bay, overflow section with crest at elevation 941, chute on a 1 on 7 slope, and stilling basin with floor at elevation 855. The spillway will be 50 feet wide throughout its length. The overflow section and upper part of the chute will be founded on earth, with the lower part of the chute and the stilling basin founded on rock.

(c) The outlet works with invert at river bottom will be founded on rock in the center of the valley. They will consist of a 5'-3" x 6'-6" concrete cut-and-cover conduit, stilling basin, and a gate structure complete with sluice gate for flood control releases. Two 30" x 30" water quality control gates will be placed between the top of the joint-use pool and the conduit.

(d) Gates will be manually operated with provision for portable power. Access to the top of the gate structure will be by foot bridge.

(3) Relocations and alterations.

(a) Roads. The reservoir necessitates building 0.3 mile of new road and improving 0.2 mile of existing road. Cost estimates for the individual relocations shown below may be found in APPENDIX T.

TABLE E-42
Road alterations at Little Dry Fork Creek Reservoir (I-23)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
C-1	0.2	-	County road to maintain east-west service north of reservoir.
A-1	-	0.3	Road across dam.

(b) Pipelines. There are no pipeline crossings which will require alteration or relocation.

(c) Power and telephone lines. Approximately 3 miles of power distribution lines, 0.3 mile of 33 KV transmission lines, and 3 miles of telephone lines will require alteration due to construction of this reservoir.

(d) Cemeteries. There were no cemeteries found by field reconnaissance. However, a liberal allowance for cemetery relocation cost is included in the cost estimate.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-43
Land requirements of Little Dry Fork Creek Reservoir (I-23)

Reservoir operation and construction	Acres
Below maximum flood pool	
Cleared land	270
Timberland	630
Existing streams	50

TABLE E-43 (Cont'd)

Reservoir operation and construction		Acres
Above maximum flood pool (300' strip)		450
Dam and working areas		300
	Subtotal	1,700
Additional land for recreation (others)		1,100
Additional land for recreation (CE)		100
	Total	2,900

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-44
Cost estimate of Little Dry Fork Creek Reservoir (I-23)

Item	Cost
Lands and damages	$ 520,000
Relocations	236,000
Reservoir clearing	35,000
Dam and appurtenant works	2,490,000
Fish and wildlife facilities	3,000
Access road	127,000
Recreation facilities	173,000
Buildings, grounds, and utilities	182,000
Permanent operating equipment	74,000
Engineering and design	677,000
Supervision and administration	353,000
Total	$4,870,000

f. Spring Creek Reservoir (I-28) (PLATES E-30 and E-31)

(1) Location. This dam is located at mile 2.0 on Spring Creek, a tributary of Dry Fork, which it enters 48 miles above its confluence with the Meramec River at mile 167.8. The total drainage area above the damsite is 44 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 1,465 feet and rise approximately 74 feet above

the valley floor. The crown width at crest elevation 1,124 will be 30 feet. The upstream slope of the embankment will be 1 on 3 down to elevation 1,104 and 1 on 3.5 down to the valley floor. The downstream slope will be 1 on 3. Internal drainage for the embankment will be provided by a chimney drain and filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 1079.

(b) The grassed spillway will be placed on the right abutment. A concrete apron will be provided along the crest at elevation 1,112, which will be 625 feet wide.

(c) The outlet works with invert at river bottom will be founded on rock in the center of the valley. They will consist of a 5'-6" x 7'-6" concrete cut-and-cover conduit, stilling basin, and a gate structure complete with sluice gate for flood control releases. Two 30" x 30" water quality control gates will be placed between the top of the joint-use pool and the conduit.

(d) Gates will be manually operated with provision for portable power. Access to the top of the gate structure will be by foot bridge.

(3) Relocations and alterations.

(a) Roads. The reservoir necessitates building 2.3 miles of new road and improving 1.1 miles of existing roads. Cost estimates for the individual relocations shown in the table below may be found in APPENDIX T.

TABLE E-45
Road alterations at Spring Creek Reservoir (I-28)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
S-1	1.1	-	Raise Route U across two arms of the reservoir.
A-1	-	2.3	Road across dam.

(b) Pipelines. There are no pipeline crossings.

(c) Power and telephone lines. Approximately 6 miles of power distribution lines and 5 miles of telephone lines will require alteration due to construction of this reservoir.

(d) Cemeteries. There were no cemeteries found by field reconnaissance. However, a liberal allowance for cemetery relocation cost is included in the cost estimate.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-46
Land requirements of Spring Creek Reservoir (I-28)

Reservoir operation and construction		Acres
Below maximum flood pool		
Cleared land		1,230
Timberland		480
Existing streams		40
Above maximum flood pool (300' strip)		850
Dam and working areas		300
Rights-of-way for relocations		20
	Subtotal	2,920
Additional land for recreation (others)		1,300
Additional land for recreation (CE)		300
	Total	4,520

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-47
Cost estimate of Spring Creek Reservoir (I-28)

Item	Cost
Lands and damages	$ 726,000
Relocations	805,000
Reservoir clearing	63,000
Dam and appurtenant works	1,536,000
Fish and wildlife facilities	3,000
Access road	260,000
Recreation facilities	160,000
Buildings, grounds, and utilities	182,000

TABLE E-47 (Cont'd)

Item		Cost
Permanent operating equipment		$ 88,000
Engineering and design		632,000
Supervision and administration		325,000
	Total	$ 4,780,000

29. BOURBEUSE RIVER SUB-BASIN

a. Redoak Creek Reservoir (I-32) (PLATES E-32 and E-33)

(1) Location. This reservoir is located on Redoak Creek with dam 1.3 miles above its junction with the Bourbeuse River at mile 83.0. The total drainage area above the damsite is 60 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 2,205 feet and rise approximately 55 feet above the valley floor. The crown width at crest elevation 728 will be 30 feet. The upstream slope of the embankment will be 1 on 3 down to elevation 708 and 1 on 3.5 down to the valley floor. The downstream slope will be 1 on 3. Internal drainage for the embankment will be provided by a chimney drain and filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of revetment down to elevation 689.

(b) The grassed spillway will be placed on the left abutment. A concrete apron 1,100 feet wide will be provided along the crest at elevation 718.

(c) The outlet works with invert at river bottom will be founded on rock in the center of the valley. They will consist of a 6'-3" x 7'-9" concrete cut-and-cover conduit, stilling basin, and a gate structure complete with sluice gate for flood control releases. Two 30" x 30" water quality control gates will be placed between the top of the joint-use pool and the conduit.

(d) Gates will be manually operated with provision for portable power. Access to the top of the gate structure will be by foot bridge.

(3) Relocations and alterations.

(a) Roads. This reservoir necessitates building 1.4 miles of new road and improving 0.5 mile of existing road. Cost estimates for the individual relocations shown in the following table may be found in APPENDIX T.

TABLE E-48
Road alterations at Redoak Creek Reservoir (I-32)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
S-1	0.5	-	Raise Route T across reservoir.
S-2	-	0.9	Relocate Route H out of dam construction area.
A-1	-	0.5	Road across dam.

(b) Pipelines. There are no pipeline crossings.

(c) Power and telephone lines. Approximately 5 miles of power distribution lines, 0.3 mile of 169 KV power transmission lines, and 5 miles of telephone lines will require alteration due to construction of this reservoir.

(d) Cemeteries. There were no cemeteries found by field reconnaissance. However, a liberal allowance for cemetery relocation cost is included in the cost estimate.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-49
Land requirements of Redoak Creek Reservoir (I-32)

Reservoir operation and construction	Acres
Below maximum pool	
Cleared land	1,210
Timberland	800
Existing streams	40
Above maximum pool (300' strip)	1,000
Dam and working areas	250
Rights-of-way for relocations	5
Subtotal	3,305

TABLE E-49 (Cont'd)

Reservoir operation and construction	Acres
Additional land for recreation (others)	400
Additional land for recreation (CE)	200
Total	3,905

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-50
Cost estimate of Redoak Creek Reservoir (I-32)

Item	Cost
Lands and damages	$ 814,000
Relocations	346,000
Reservoir clearing	60,000
Dam and appurtenant works	1,794,000
Fish and wildlife facilities	3,000
Access road	155,000
Recreation facilities	100,000
Buildings, grounds, and utilities	182,000
Permanent operating equipment	81,000
Engineering and design	579,000
Supervision and administration	296,000
Total	$ 4,410,000

b. Little Bourbeuse River Reservoir (I-33A) (PLATES E-34 and E-35)

(1) Location. This reservoir is located on the Little Bourbeuse River with the dam 5.1 miles above the junction with the Bourbeuse at mile 89.9. The total drainage area above the damsite is 52 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 2,700 feet and rise approximately 90 feet above the valley floor. The crown width at crest elevation 797 will be 30 feet. The upstream slope of the embankment will be 1 on 3 down to elevation 777 and 1 on 3.5 down to the valley floor. The downstream slope will be 1 on 3. Internal drainage for the embankment will be provided by a chimney drain and filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 743.

(b) The chute spillway will be of reinforced concrete founded on the left abutment. It will consist of entrance bay, overflow section with crest at elevation 777, chute on a 1 on 7 slope, and stilling basin with floor at elevation 690. The spillway will be 50 feet wide throughout its length. The overflow section and upper part of the chute will be founded on earth with the lower part of the chute and the stilling basin founded on rock.

(c) The outlet works with invert at river bottom will be founded on rock in the left of the valley. They will consist of a 5'-6" x 7'-6" concrete cut-and-cover conduit, a stilling basin, and gate structure complete with sluice gate for flood control releases. Two 30" x 30" water quality control gates will be placed between the top of the joint-use pool and the conduit.

(d) Gates will be manually operated with provision for portable power. Access to the top of the gate structure will be by foot bridge.

(3) Relocations and alterations.

(a) Roads. The reservoir necessitates building 1.1 miles of new road and improving 1.4 miles of existing roads. Cost estimates for the individual relocations shown in the following table may be found in APPENDIX T.

TABLE E-51
Road alterations at Little Bourbeuse River Reservoir (I-33A)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
C-1	0.7	-	County road connecting road nets east and west of Three Mile Creek.
C-2	0.7	-	County road connecting road nets east and west of Little Bourbeuse River.
A-1	-	1.1	Road across dam.

(b) Pipelines. There are no pipeline crossings.

(c) Power and telephone lines. Approximately 8 miles of power distribution lines and 6 miles of telephone lines will require alteration due to construction of this reservoir.

(d) Cemeteries. Field reconnaissance found 50 graves within the reservoir area to be relocated to higher ground.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-52
Land requirements of Little Bourbeuse River Reservoir (I-33A)

Reservoir operation and construction		Acres
Below maximum pool		
Cleared land		710
Timberland		720
Existing streams		20
Above maximum pool (300' strip)		750
Dam and working areas		300
Rights-of-way for relocations		10
	Subtotal	2,510
Additional land for recreation (others)		800
Additional land for recreation (CE)		200
	Total	3,510

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-53
Cost estimate of Little Bourbeuse River Reservoir (I-33A)

Item		Cost
Lands and damages		$ 400,000
Relocations		281,000
Reservoir clearing		40,000
Dam and appurtenant works		2,742,000
Fish and wildlife facilities		3,000
Access road		379,000
Recreation facilities		50,000
Buildings, grounds, and utilities		182,000
Permanent operating equipment		81,000
Engineering and design		621,000
Supervision and administration		371,000
	Total	$ 5,150,000

c. Brush Creek Reservoir (I-35A) (PLATES E-36 and E-37)

(1) Location. This reservoir is located on Brush Creek with the dam 2.5 miles above creek junction with the Bourbeuse River at mile 105.3. The total drainage area above the damsite is 69 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 2,400 feet and rise approximately 70 feet above the valley floor. The crown width at crest elevation 809 will be 30 feet. The upstream slope of the embankment will be 1 on 3 down to elevation 789 and 1 on 3.5 down to the valley floor. The downstream slope will be 1 on 3. Internal drainage for the embankment will be provided by a chimney drain and filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of revetment down to elevation 756.

(b) The chute spillway will be of reinforced concrete founded on the left abutment. It will consist of entrance bay, overflow section with crest at elevation 786, chute on a 1 on 5 slope, and stilling basin with floor at elevation 705. The spillway will be 50 feet wide throughout its length. The overflow section and the upper part of the chute will be founded on earth with the lower part of the chute and the stilling basin founded on rock.

(c) The outlet works with invert at river bottom will be founded on rock in the left of the valley. They will consist of a 6'-6" x 8'-0" concrete cut-and-cover conduit, stilling basin, and a gate structure complete with sluice gate for flood control releases. Two 30" x 30" water quality control gates will be placed between the top of the joint-use pool and the conduit.

(d) Gates will be manually operated with provision for portable power. Access to the top of the gate structure will be by foot bridge.

(3) Relocations and alterations.

(a) Roads. The reservoir necessitates building 3.1 miles of new road and improving 0.7 mile of existing road. Cost estimates for the individual relocations shown below may be found in APPENDIX T.

TABLE E-54
Road alterations at Brush Creek Reservoir (I-35A)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
S-1	0.3	-	Raise Route 19 across reservoir.
S-2	0.4	-	Raise Route C across reservoir.
C-1	-	0.4	County road to maintain access to area west of Oak Hill, Missouri.
C-2	-	0.7	County road to maintain north-south service in road net west of reservoir.
C-3	-	0.8	County road to maintain access to area southwest of Oak Hill, Missouri.
A-1	-	1.2	Road across dam.

(b) Pipelines. There are no pipeline crossings.

(c) Power and telephone lines. Approximately 11 miles of power distribution lines and 8 miles of telephone lines will require alteration due to construction of this reservoir.

(d) Cemeteries. There were no cemeteries found by field reconnaissance. However, a liberal allowance for cemetery relocation cost is included in the cost estimate.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-55
Land requirements of Brush Creek Reservoir (I-35A)

Reservoir operation and construction	Acres
Below maximum pool	
Cleared land	910
Timberland	400
Existing streams	90

TABLE E-55 (Cont'd)

Reservoir operation and construction		Acres
Above maximum pool (300' strip)		700
Dam and working areas		300
Rights-of-way for relocations		30
	Subtotal	2,430
Additional land for recreation (others)		900
Additional land for recreation (CE)		200
	Total	3,530

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates are found in APPENDIX T.

TABLE E-56
Cost estimate of Brush Creek Reservoir (I-35A)

Item	Cost
Lands and damages	$ 466,000
Relocations	580,000
Reservoir clearing	60,000
Dam and appurtenant works	2,593,000
Fish and wildlife facilities	3,000
Access road	168,000
Recreation facilities	50,000
Buildings, grounds, and utilities	182,000
Permanent operating equipment	81,000
Engineering and design	651,000
Supervision and administration	366,000
Total	$ 5,200,000

d. Peavine Creek Reservoir (I-21) (PLATES E-38 and E-39)

(1) Location. This dam is located at mile 1.5 on Peavine Creek, a tributary of Dry Fork, which it enters 15 miles above its confluence with the Bourbeuse at mile 100.7. The total drainage area above the damsite is 23.5 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 2,275 feet and rise approximately 40 feet above the valley floor. The crown width at crest elevation 916 will be 30 feet.

The upstream slope of the embankment will be 1 on 3 down to elevation 896 and 1 on 3.5 down to the valley floor. The downstream slope will be 1 on 3. Internal drainage for the embankment will be provided by a chimney drain and filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 885.

(b) The grassed spillway will be placed on the right abutment. A concrete apron 365 feet wide will be provided along the crest at elevation 904.

(c) The outlet works with invert at river bottom will be founded on rock in the left of the valley. They will consist of a 4'-9" x 6'0" concrete cut-and-cover conduit, stilling basin, and a gate structure complete with sluice gate for flood control releases. Two 30" x 30" water quality control gates will be placed between the top of the joint-use pool and the conduit.

(d) Gates will be manually operated with provision for portable power. Access to the top of the gate structure will be by foot bridge.

(3) Relocations and alterations.

(a) Roads. The reservoir necessitates building 2.0 miles of new road and improving 0.3 mile of existing roads. Cost estimates for the individual relocations shown below may be found in APPENDIX T.

TABLE E-57
Road alterations at Peavine Creek Reservoir (I-21)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
S-1	0.3	-	Raise Route F across reservoir.
A-1	-	2.0	Road across dam.

(b) Pipelines. There are no pipeline crossings.

(c) Power and telephone lines. Approximately 3 miles of power distribution lines and 2 miles of telephone lines will require alteration due to construction of this reservoir.

(d) Cemeteries. There were no cemeteries found by field reconnaissance. However, a liberal allowance for cemetery relocation cost is included in the cost estimate.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-58
Land requirements of Peavine Creek Reservoir (I-21)

Reservoir operation and construction		Acres
Below maximum flood pool		
Cleared land		530
Timberland		240
Existing streams		30
Above maximum flood pool (300' strip)		400
Dam and working areas		300
Rights-of-way for relocations		10
	Subtotal	1,510
Additional land for recreation (others)		300
Additional land for recreation (CE)		100
	Total	1,910

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-59
Cost estimate of Peavine Creek Reservoir (I-21)

Item		Cost
Lands and damages		$ 265,000
Relocations		256,000
Reservoir clearing		32,000
Dam and appurtenant works		1,557,000
Fish and wildlife facilities		3,000
Access road		228,000
Recreation facilities		50,000
Buildings, grounds, and utilities		182,000
Permanent operating equipment		74,000
Engineering and design		527,000
Supervision and administration		266,000
	Total	$ 3,440,000

e. Bourbeuse River Reservoir (I-38) (PLATES E-40 and E-41)

(1) Location. This reservoir is located on the upper Bourbeuse with dam at mile 127.3. The total drainage area above the damsite is 121 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 3,000 feet and rise approximately 60 feet above the valley floor. The crown width at crest elevation 880 will be 30 feet. The upstream slope of the embankment will be 1 on 3 down to elevation 860 and 1 on 3.5 down to the valley floor. The downstream slope will be 1 on 3. Internal drainage for the embankment will be provided by a chimney drain and filter blanket. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment. The upstream slope will be protected with 24 inches of rock revetment down to elevation 830.

(b) The chute spillway will be of reinforced concrete founded on the left abutment. It will consist of entrance bay, overflow section with crest at elevation 857, chute on a 1 on 10 slope, and stilling basin with floor at elevation 788. The spillway will be 50 feet wide throughout its length. The overflow section and upper part of the chute will be founded on earth with the lower part of the chute and the stilling basin founded on rock.

(c) The outlet works with invert at river bottom will be founded on rock in the left of the valley. They will consist of an 8'-0" x 10'-0" concrete cut-and-cover conduit, stilling basin, and a gate structure complete with sluice gate for flood control releases. Two 30" x 30" water quality control gates will be placed between the top of the joint-use pool and the conduit.

(d) Gates will be manually operated with provisions for portable power. Access to the top of the gate structure will be by foot bridge.

(3) Relocations and alterations.

(a) Roads. The reservoir necessitates building 3.1 miles of new road and improving 0.6 mile of existing road. Cost estimates for the individual relocations shown below may be found in APPENDIX T.

TABLE E-60
Road alterations at Bourbeuse River Reservoir (I-38)

Designation	Length of alteration (miles)	Length of new road (miles)	Description
C-1	-	1.2	County road to provide access to area south of Lanes Fork.
C-2	0.6	-	Provide crossing of Bourbeuse River in southern end of reservoir.
A-1	-	1.9	Road across dam.

(b) Pipelines. There are no pipeline crossings.

(c) Power and telephone lines. Approximately 8 miles of power distribution lines and 6 miles of telephone lines will require alteration due to construction of this reservoir.

(d) Cemeteries. There were no cemeteries found by field reconnaissance. However, a liberal allowance for cemetery relocation cost is included in the cost estimate.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-61
Land requirements of Bourbeuse River Reservoir (I-38)

Reservoir operation and construction		Acres
Below maximum flood pool		
Cleared land		1,740
Timberland		1,180
Existing streams		30
Above maximum flood pool (300' strip)		1,450
Dam and working areas		300
Rights-of-way for relocations		25
	Subtotal	4,725
Additional land for recreation (others)		1,000
Additional land for recreation (CE)		300
	Total	6,025

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-62
Cost estimate of Bourbeuse River Reservoir (I-38)

Item	Cost
Lands and damages	$ 725,000
Relocations	279,000
Reservoir clearing	89,000
Dam and appurtenant works	2,516,000
Fish and wildlife facilities	3,000
Access road	314,000
Recreation facilities	313,000
Buildings, grounds, and utilities	194,000
Permanent operating equipment	160,000
Engineering and design	641,000
Supervision and administration	376,000
Total	$ 5,610,000

SECTION IV - DESCRIPTION OF HEADWATER RESERVOIRS

30. GENERAL

Designs of the 12 headwater reservoirs included in this appendix were furnished by the U. S. Department of Agriculture, Soil Conservation Service (SCS). These dams were designed in accordance with SCS criteria. Storage volume of the pools was determined by the Corps of Engineers. Cost estimates furnished by the SCS were increased for the following two reasons: unit prices were changed to agree with Corps of Engineers' costs used throughout this report and appendices; recreation and fish and wildlife facilities were added to all headwater sites. TABLE E-63 gives pertinent data on the 12 headwater reservoirs retained for economic analysis. TABLE E-64 summarizes land requirements for these reservoirs.

31. BIG RIVER SUB-BASIN

a. Dry Creek Reservoir (H-3).

(1) Location. This reservoir is located on Dry Creek with the damsite 7.0 miles above its confluence with Big River at mile 32.0. The total drainage area above the damsite is 9.2 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 1,050 feet and rise approximately 40 feet above the valley floor. The crown width at crest elevation 635 will be 20 feet. The upstream slope of the embankment will be 1 on 3 and the downstream slope will be 1 on 2.5. There will also be a 10-foot wide berm at elevation 617 on both the upstream and downstream slopes. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment.

(b) The grassed spillway will be placed in the left abutment and will have a crest at elevation 629. The spillway will be 185 feet wide. No stilling basin will be provided.

(c) The outlet works with invert at elevation 592 will be founded on earth in the center of the valley. They will consist of a 36-inch reinforced concrete pipe conduit and an uncontrolled gate structure.

(3) Relocations.

(a) Roads. This reservoir would necessitate building approximately 0.5 mile of county road.

(b) Cemeteries. There were no cemeteries found by field reconnaissance. However, a liberal allowance for cemetery relocation is included in the cost estimate.

TABLE E-63
Headwater reservoir data sheet

	H-3	H-9	H-4	H-40	H-25	H-5A	H-8	H-10A	H-6	H-11A	H-13A	H-31
Top dam elevation (m.s.l.)	635	955	683	685	1,054	555	723	1,015	543	824	818	895
Spillway crest elevation (m.s.l.)	629	948	673	675	1,044	549	717	1,006	536	818	811	885
Normal pool elevation (m.s.l.)	618	935	673	675	1,038	537	706	997	536	806	793	885
Minimum conservation pool elevation (m.s.l.) (100-year sediment capacity)	615	933	650	663	1,027	535	692	994	521	802	793	874
River bottom elevation (m.s.l.)	592	908	617	632	988	512	664	968	492	776	764	850
Drainage area (sq. mi.)	9.2	8.0	8.2	3.9	13.3	3.1	17.8	4.2	10.4	10.6	21.1	6.2
Storage (ac. ft.)												
Total	2,750	2,240	2,080	900	2,660	950	5,960	1,240	2,760	3,050	5,580	1,760
Flood control	1,850	1,430	-	-	700	640	2,840	670	-	1,880	4,170	-
Joint-use	900	810	2,080	900	1,960	310	3,120	570	2,760	1,170	1,410	1,760
Sediment	670	620	650	380	870	230	1,040	430	730	820	1,060	510
Net joint-use	230	190	1,430	520	1,090	80	2,080	140	2,030	350	350	1,250
Pool areas (acres)												
Maximum spillway surcharge	270	210	130	60	180	100	350	120	280	270	550	260
Flood control pool	200	150	-	-	140	80	290	90	-	200	400	-
Normal pool	100	100	100	50	100	50	200	50	200	100	150	200
Minimum conservation pool	90	60	40	30	70	30	100	40	60	80	140	80
Dam dimensions												
Crest length (feet)	1,050	1,180	610	580	300	980	1,380	690	1,090	760	1,270	1,510
Base width (feet)	200	230	370	310	400	230	320	270	230	260	270	230
Volume (cubic yard)	90,200	154,900	102,800	144,400	79,600	38,200	360,300	138,000	168,000	29,000	240,200	170,500
Spillway												
Type	Earth	Earth	Chute	Chute	Chute	Earth	Earth ramp	Chute	Rock	Earth	Earth	Earth
Length (feet)	185	140	162	90	90	92	200	75	75	180	250	135
Capacity (c.f.s.)	9,600	7,800	10,000	5,775	6,620	3,345	17,200	3,775	4,400	9,400	13,500	6,500
Maximum surcharge (feet)	6.0	7.0	9.0	8.9	8.7	5.4	5.3	7.8	6.6	6.0	6.8	6.4
Freeboard	0	0	1.0	1.1	1.3	0.6	0.7	1.2	0.4	0	0.2	3.6
Outlets												
Size	36" dia.	36" dia.	36" dia.	12" dia.	24" dia.	24" dia.	24" dia.	24" dia.	24" dia.	24" dia.	24" dia.	36" dia.
Maximum controlled discharge (c.f.s.)	205	196	212	-	302	75	428	75	375	293	493	184

TABLE E-64
Headwater reservoirs land requirements
(acres)

Reservoir	Land required up to top pool elevation	Access land reqd. from top pool elev. back 300 ft. horizontal plus dam, spillway and borrow areas	Land reqd. for initial CE recreation development	Land reqd. to replace State lands inundated	Land reqd. for land-based recreation in Clark National Forest	Land reqd. for relocations	Land reqd. for future recreation development and for mitigation of wildlife habitat losses	Total land requirements
H-3	200	240	30	-	-	-	370	840
H-9	150	150	20	-	-	-	320	640
H-4	100	280	20	-	-	-	420	820
H-40	50	180	10	-	-	-	830	1,070
H-25	140	310	20	-	230	-	250	950
H-5A	80	270	30	-	-	-	270	650
H-8	290	840	40	-	-	-	810	1,980
H-10A	90	250	10	-	180	-	100	630
H-6	200	550	30	-	-	-	630	1,410
H-11A	200	400	30	-	-	-	420	1,050
H-13A	400	1,180	60	-	-	-	680	2,320
H-31	200	400	30	-	-	-	290	920
Total for headwater reservoirs	2,100	5,050	330	-	410	-	5,390	13,280

R Apr 64

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-65
Land requirements of Dry Creek Reservoir (H-3)

Reservoir operation and construction	Acres
Below maximum flood pool	
Cleared land	130
Timberland	60
Existing streams	10
Above maximum flood pool (300' strip)	165
Dam and working areas	75
Subtotal	440
Additional land for recreation (others)	370
Additional land for recreation (CE)	30
Total	840

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimate may be found in APPENDIX T.

TABLE E-66
Cost estimate of Dry Creek Reservoir (H-3)

Item	Cost
Lands and damages	$161,000
Relocations	5,000
Reservoir clearing	6,000
Dam and appurtenant works	124,000
Fish and wildlife facilities	3,000
Access road	8,000
Recreation facilities	25,000
Buildings, grounds, and utilities	5,000
Permanent operating equipment	7,000
Engineering and design	46,000
Supervision and administration	29,000
Total	$419,000

b. Bates Creek Reservoir (H-9).

(1) Location. This reservoir is located on Bates Creek with the damsite 2.7 miles above its confluence with Breton Creek. Breton Creek merges with Mineral Fork Creek and into the Big River at mile 60.6. The total drainage area above the damsite is 8.0 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 1,200 feet and rise approximately 50 feet above the valley floor. The crown width at crest elevation 955 will be 20 feet. The upstream slope of the embankment will be 1 on 3 and the downstream slope will be 1 on 2.5. There will also be a 10-foot wide berm at elevation 934 on both the upstream and downstream slopes. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment.

(b) The grassed spillway will be placed in the right abutment and will have a crest at elevation 948. The spillway will be 140 feet wide. No stilling basin will be provided.

(c) The outlet works with invert at elevation 908 will be founded on earth in the center of the valley. They will consist of a 36-inch reinforced concrete pipe conduit and an uncontrolled gate structure.

(3) Relocations. The reservoir would necessitate building approximately 1.0 mile of county road.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-67
Land requirements of Bates Creek Reservoir (H-9)

Reservoir operation and construction	Acres
Below maximum flood pool	
Cleared land	113
Timberland	30
Existing streams	7
Above maximum flood pool (300' strip)	140
Dam and working areas	10
Subtotal	300
Additional land for recreation (others)	320
Additional land for recreation (CE)	20
Total	640

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-68
Cost estimate of Bates Creek Reservoir (H-9)

Item	Cost
Lands and damages	$136,000
Relocations	9,000
Reservoir clearing	6,000
Dam and appurtenant works	240,000
Fish and wildlife facilities	3,000
Access road	21,000
Recreation facilities	25,000
Buildings, grounds, and utilities	5,000
Permanent operating equipment	7,000
Engineering and design	79,000
Supervision and administration	35,000
Total	$566,000

c. Cabanne Course Reservoir (H-4).

(1) Location. This reservoir is located on Cabanne Course with the damsite 0.3 mile above its confluence with the Big River at mile 81.15. The total drainage area above the damsite is 8.2 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 880 feet and rise approximately 60 feet above the valley floor. The crown width at crest elevation 683 will be 20 feet. Upstream and downstream slopes of the embankment will be 1 on 3. On the upstream slope, there will be a 20-foot wide berm at elevation 654. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment.

(b) The chute spillway will be of reinforced concrete founded on earth and located approximately in the center of the valley. It will consist of entrance bay, overflow section with crest at elevation 673, chute on a 1 on 3 slope, and stilling basin at elevation 617. The spillway will be 162 feet wide.

(c) The outlet works will consist of an uncontrolled gate structure and a reinforced concrete pipe conduit at elevation 617.

(3) Relocations. The reservoir would necessitate building approximately 1.0 mile of county road and one new bridge.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-69
Land requirements of Cabanne Course Reservoir (H-4)

Reservoir operation and construction	Acres
Below maximum pool	
Cleared land	15
Timberland	80
Existing streams	5
Above maximum pool (300' strip)	230
Dam and working areas	50
Subtotal	380
Additional land for recreation (others)	420
Additional land for recreation (CE)	20
Total	820

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-70
Cost estimate of Cabanne Course Reservoir (H-4)

Item	Cost
Lands and damages	$178,000
Relocations	25,000
Reservoir clearing	8,000
Dam and appurtenant works	337,000
Fish and wildlife facilities	3,000
Access road	5,000
Recreation facilities	25,000
Buildings, grounds, and utilities	5,000
Permanent operating equipment	7,000
Engineering and design	104,000
Supervision and administration	43,000
Total	$740,000

d. Coonville Creek Reservoir (H-40).

(1) Location. This reservoir is located on Coonville Creek with the damsite 0.1 mile above its confluence with the Big River at mile 84.75. The total drainage area above the damsite is 3.9 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 700 feet and rise approximately 50 feet above the valley floor. The crown width at crest elevation 685 will be 20 feet. Upstream and downstream slopes of the embankment would be 1 on 3. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment.

(b) The chute spillway will be of reinforced concrete founded on earth and located approximately in the center of the valley. It will consist of entrance bay, overflow section with crest at elevation 675, chute on a 1 on 3 slope, and stilling basin at elevation 632. The spillway will be 90 feet wide.

(c) The outlet works will consist of a dewatering structure and reinforced concrete pipe conduit at elevation 632.

(3) Relocations. No relocations will be required.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-71
Land requirements of Coonville Creek Reservoir (H-40)

Reservoir operation and construction	Acres
Below maximum pool	
Cleared land	3
Timberland	44
Existing streams	3
Above maximum pool (300' strip)	130
Dam and working areas	50
Subtotal	230
Additional land for recreation (others)	830
Additional land for recreation (CE)	10
Total	1,070

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-72
Cost estimate of Coonville Creek Reservoir (H-40)

Item	Cost
Lands and damages	$138,000
Reservoir clearing	8,000
Dam and appurtenant works	203,000
Access road	21,000
Recreation facilities	25,000
Buildings, grounds, and utilities	5,000
Permanent operating equipment	7,000
Engineering and design	67,000
Supervision and administration	30,000
Total	$504,000

e. Big River Reservoir (H-25).

(1) Location. This reservoir is located on the headwaters of the Big River with the damsite at mile 134.5. The total drainage area above the damsite is 13.3 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment would have a crest length of about 400 feet and rise approximately 70 feet above the valley floor. The crown width at crest elevation 1,054 would be 20 feet. Upstream and downstream slopes of the embankment would be 1 on 3. On the upstream slope, there will be a 20-foot wide berm at elevation 1,030. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment.

(b) The chute spillway will be of reinforced concrete founded on earth and located approximately in the center of the valley. It will consist of entrance bay, overflow section with crest at elevation 1,044, chute on a 1 on 3 slope, and stilling basin at elevation 988. The spillway will be 90 feet wide.

(c) The outlet works with invert at elevation 988 will be founded on earth in the center of the valley. They will consist of a reinforced concrete pipe conduit and an uncontrolled gate structure.

(3) Relocations. The reservoir would necessitate building approximately 2.0 miles of county road and one new culvert.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-73
Land requirements of Big River Reservoir (H-25)

Reservoir operation and construction	Acres
Below maximum flood pool	
Cleared land	95
Timberland	38
Existing streams	7
Above maximum flood pool (300' strip)	260
Dam and working areas	50
Subtotal	450
Additional land for recreation (others)	230
Additional land for recreation (CE)	20
Replacement of wildlife habitat	250
Total	950

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-74
Cost estimate of Big River Reservoir (H-25)

Item	Cost
Lands and damages	$162,000
Relocations	21,000
Reservoir clearing	8,000
Dam and appurtenant works	209,000
Fish and wildlife facilities	3,000
Access road	23,000
Recreation facilities	25,000
Buildings, grounds, and utilities	5,000
Permanent operating equipment	7,000
Engineering and design	75,000
Supervision and administration	33,000
Total	$571,000

32. MERAMEC RIVER SUB-BASIN

a. Brady Creek Reservoir (H-5A).

(1) Location. This reservoir is located on Brady Creek with the damsite 0.2 mile above its confluence with Calvey Creek. Calvey Creek enters the Meramec River at mile 58.3. The total drainage area above the damsite is 3.1 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 1,000 feet and rise approximately 40 feet above the valley floor. The crown width at crest elevation 555 will be 20 feet. The upstream slope of the embankment will be 1 on 3 and the downstream slope will be 1 on 2.5. There will also be a 10-foot wide berm at elevation 536 on both the upstream and downstream slopes. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment.

(b) The grassed spillway will be placed in the right abutment and will have a crest at elevation 549. No stilling basin will be provided. The spillway will be 92 feet wide.

(c) The outlet works with invert at elevation 512 will be founded on earth in the center of the valley. They will consist of a 36-inch reinforced concrete pipe and an uncontrolled gate structure.

(3) Relocations. This reservoir would necessitate building 0.3 mile of county road and one new bridge.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-75
Land requirements of Brady Creek Reservoir (H-5A)

Reservoir operation and construction	Acres
Below maximum flood pool	
Cleared land	55
Timberland	20
Existing streams	5
Above maximum flood pool (300' strip)	195
Dam and working areas	75
Subtotal	350
Additional land for recreation (others)	270
Additional land for recreation (CE)	30
Total	650

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-76
Cost estimate of Brady Creek Reservoir (H-5A)

Item	Cost
Lands and damages	$ 87,000
Relocations	26,000
Reservoir clearing	8,000
Dam and appurtenant works	124,000
Access road	2,000
Recreation facilities	25,000
Buildings, grounds, and utilities	5,000
Permanent operating equipment	7,000
Engineering and design	49,000
Supervision and administration	29,000
Total	$362,000

b. Little Indian Creek Reservoir (H-8).

(1) Location. This reservoir is located on Little Indian Creek with the damsite 4.8 miles above its confluence with Indian Creek. Indian Creek enters the Meramec River at mile 85.0. The total drainage area above the damsite is 17.8 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment would have a crest length of about 1,625 feet and rise approximately 60 feet above the valley floor. The crown width at crest elevation 723 would be 20 feet. The upstream slope of the embankment will be 1 on 3 and the downstream slope will be 1 on 2.5. There will also be a 10-foot wide berm at elevation 694 on both the upstream and downstream slopes. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment.

(b) The grassed spillway will be placed in the right abutment and will have a crest at elevation 717. The spillway will be 200 feet wide. No stilling basin will be provided.

(c) The outlet works with invert at elevation 664 will be founded on earth in the center of the valley. They will consist of a 36-inch reinforced concrete pipe conduit and an uncontrolled gate structure.

(3) Relocations. The reservoir would necessitate building approximately 0.3 mile of county road.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-77
Land requirements of Little Indian Creek Reservoir (H-8)

Reservoir operation and construction	Acres
Below maximum flood pool	
Cleared land	200
Timberland	75
Existing streams	15
Above maximum flood pool (300' strip)	765
Dam and working areas	75
Subtotal	1,130
Additional land for recreation (others)	810
Additional land for recreation (CE)	40
Total	1,980

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-78
Cost estimate of Little Indian Creek Reservoir (H-8)

Item	Cost
Lands and damages	$ 303,000
Relocations	24,000
Reservoir clearing	8,000
Dam and appurtenant works	409,000
Fish and wildlife facilities	3,000
Access road	21,000
Recreation facilities	50,000
Buildings, grounds, and utilities	5,000
Permanent operating equipment	7,000
Engineering and design	132,000
Supervision and administration	58,000
Total	$1,020,000

c. Lost Creek Reservoir (H-10A).

(1) Location. This reservoir is located on Lost Creek with the damsite 8.0 miles above its confluence with Courtois Creek. Courtois Creek merges with the Huzzah and the Huzzah with the Meramec River at mile 130.5. The total drainage area above the damsite is 4.2 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment will have a crest length of about 800 feet and rise approximately 50 feet above the valley floor. The crown width at crest elevation 1,015 will be 20 feet. Upstream and downstream slopes of the embankment would be 1 on 3. On the upstream slope, there will be a 20-foot wide berm at elevation 996. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment.

(b) The chute spillway will be of reinforced concrete founded on earth and located approximately in the center of the valley. It will consist of an entrance bay, overflow section with crest at elevation 1,007, chute on a 1 on 3 slope, and a stilling basin at elevation 968. The spillway will be 75 feet wide.

(c) The outlet works with invert at elevation 968 will be founded on earth in the center of the valley. They will consist of a reinforced concrete pipe conduit and an uncontrolled gate structure.

(3) Relocations.

(a) Roads. The reservoir would necessitate building approximately 0.2 mile of county road and one new bridge.

(b) Power lines. The reservoir would require relocation of 0.1 mile of transmission line.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-79
Land requirements of Lost Creek Reservoir (H-10A)

Reservoir operation and construction	Acres
Below maximum flood pool	
Cleared land	45
Timberland	40
Existing streams	5
Above maximum flood pool (300' strip)	200
Dam and working areas	50
Subtotal	340
Additional land for recreation (others)	180
Additional land for recreation (CE)	10
Replacement of wildlife habitat	100
Total	630

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-80
Cost estimate of Lost Creek Reservoir (H-10A)

Item	Cost
Lands and damages	$ 79,000
Relocations	32,000
Reservoir clearing	12,000
Dam and appurtenant works	201,000
Fish and wildlife facilities	3,000
Access road	16,000
Recreation facilities	25,000
Buildings, grounds, and utilities	5,000
Permanent operating equipment	7,000
Engineering and design	75,000
Supervision and administration	33,000
Total	$488,000

33. BOURBEUSE RIVER SUB-BASIN

a. Birch Creek Reservoir (H-6).

(1) Location. This reservoir is located on Birch Creek with the damsite 2.0 miles above its confluence with the Bourbeuse River at mile 6.1. The total drainage area above the damsite is 10.4 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment would have a crest length of about 1,100 feet and rise approximately 50 feet above the valley floor. The crown width at crest elevation 543 would be 20 feet. The upstream slope of the embankment will be 1 on 3 and the downstream slope will be 1 on 2.5. There will also be a 10-foot wide berm at elevation 523 on both the upstream and downstream slopes. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment.

(b) The grassed spillway will be placed in the right abutment and will have a crest at elevation 536. The spillway will be 75 feet wide. No stilling basin will be provided.

(c) The outlet works will consist of a dewatering structure and reinforced concrete pipe conduit at elevation 492.

(3) Relocations.

(a) Roads. The reservoir would necessitate building approximately 0.1 mile of county road.

(b) Cemetery. The reservoir would require relocation of one cemetery.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-81
Land requirements of Birch Creek Reservoir (H-6)

Reservoir operation and construction	Acres
Below maximum pool	
Cleared land	150
Timberland	40
Existing streams	10
Above maximum pool (300' strip)	475
Dam and working areas	75
Subtotal	750
Additional land for recreation (others)	630
Additional land for recreation (CE)	30
Total	1,410

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-82
Cost estimate of Birch Creek Reservoir (H-6)

Item	Cost
Lands and damages	$262,000
Relocations	11,000
Reservoir clearing	6,000
Dam and appurtenant works	329,000
Fish and wildlife facilities	3,000
Access road	8,000
Recreation facilities	50,000
Buildings, grounds, and utilities	5,000
Permanent operating equipment	7,000
Engineering and design	105,000
Supervision and administration	44,000
Total	$830,000

b. Winsell Creek Reservoir (H-11A).

(1) Location. This reservoir is located on Winsell Creek with the damsite 1.0 mile above its confluence with Spring Creek. Spring Creek enters the Bourbeuse River at mile 43.1. The total drainage area above the damsite is 10.6 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment would have a crest length of about 800 feet and rise approximately 50 feet above the valley floor. The crown width at crest elevation 824 would be 20 feet. The upstream slope of the embankment will be 1 on 3 and the downstream slope will be 1 on 2.5. There will also be a 10-foot wide berm at elevation 805 on both the upstream and downstream slopes. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment.

(b) The grassed spillway will be placed in the right abutment and will have a crest at elevation 818. The spillway will be 180 feet wide. No stilling basin will be provided.

(c) The outlet works and invert at elevation 776 will be founded on earth in the center of the valley. They will consist of a 36-inch reinforced concrete pipe conduit and an uncontrolled gate structure.

(3) Relocations. The reservoir would necessitate building approximately 0.1 mile of county road and one new culvert.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-83
Land requirements of Winsell Creek Reservoir (H-11A)

Reservoir operation and construction	Acres
Below maximum flood pool	
Cleared land	140
Timberland	50
Existing streams	10
Above maximum flood pool (300' strip)	375
Dam and working areas	75
Subtotal	600
Additional land for recreation (others)	420
Additional land for recreation (CE)	30
Total	1,050

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-84
Cost estimate of Winsell Creek Reservoir (H-11A)

Item	Cost
Lands and damages	$190,000
Relocations	7,000
Reservoir clearing	4,000
Dam and appurtenant works	79,000
Fish and wildlife facilities	3,000
Access road	4,000
Recreation facilities	25,000
Buildings, grounds, and utilities	5,000
Permanent operating equipment	7,000
Engineering and design	34,000
Supervision and administration	21,000
Total	$379,000

c. Boone Creek Reservoir (H-13A).

(1) Location. This reservoir is located on Boone Creek with the damsite 9.0 miles above its confluence with Bourbeuse River at mile 76.25. The total drainage area above the damsite is 21.1 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment would have a crest length of about 1,300 feet and rise approximately 50 feet above the valley floor. The crown width at crest elevation 818 would be 20 feet. The upstream slope of the embankment will be 1 on 3 and the downstream slope will be 1 on 2.5. There will also be a 10-foot wide berm at elevation 795 on both the upstream and downstream slopes. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment.

(b) The grassed spillway will be placed in the left abutment and will have a crest at elevation 811. The spillway will be 250 feet wide. No stilling basin will be provided.

(c) The outlet works with invert at elevation 764 will be founded on earth in the center of the valley. They will consist of a 36-inch reinforced pipe conduit and an uncontrolled gate structure.

(3) Relocations. This reservoir would necessitate building 0.1 mile of county road and one new culvert.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-85
Land requirements of Boone Creek Reservoir (H-13A)

Reservoir operation and construction	Acres
Below maximum flood pool	
Cleared land	360
Timberland	20
Existing stream	20
Above maximum flood pool (300' strip)	1,105
Dam and working areas	75
Subtotal	1,580
Additional land for recreation (others)	680
Additional land for recreation (CE)	60
Total	2,320

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-86
Cost estimate of Boone Creek Reservoir (H-13A)

Item	Cost
Lands and damages	$289,000
Relocations	4,000
Reservoir clearing	14,000
Dam and appurtenant works	288,000
Fish and wildlife facilities	3,000
Access road	2,000
Recreation facilities	25,000
Buildings, grounds, and utilities	5,000
Permanent operating equipment	7,000
Engineering and design	87,000
Supervision and administration	37,000
Total	$761,000

d. Dry Fork Creek Reservoir (H-31).

(1) Location. This reservoir is located on a tributary of Dry Fork Creek with the damsite 1.2 miles above its confluence with Dry Fork Creek. Dry Fork Creek enters the Bourbeuse River at mile 100.7. The total drainage area above the damsite is 6.2 square miles.

(2) Design details.

(a) The proposed rolled-earth embankment would have a crest length of about 1,500 feet and rise approximately 40 feet above the valley floor. The crown width at crest elevation 895 would be 20 feet. The upstream slope of the embankment will be 1 on 3 and the downstream slope will be 1 on 2.5. There will also be a 10-foot wide berm at elevation 876 on both the upstream and downstream slopes. Borrow material will be obtained from the valley soils. Studies will be made in the future to determine if material excavated from the spillway is acceptable for use in the embankment.

(b) The grassed spillway will be placed in the right abutment and will have a crest at elevation 885. The spillway will be 135 feet wide. No stilling basin will be provided.

(c) The outlet works will consist of a dewatering structure and reinforced concrete pipe conduit at elevation 850.

(3) Relocations. This reservoir would necessitate building 0.7 mile of county road and one new bridge.

(4) Land requirements. The estimated land requirements are summarized in the following table.

TABLE E-87
Land requirements of Dry Fork Creek Reservoir (H-31)

Reservoir operation and construction	Acres
Below maximum pool	
Cleared land	170
Timberland	20
Existing streams	10
Above maximum pool (300' strip)	325
Dam and working areas	75
Subtotal	600
Additional land for recreation (others)	290
Additional land for recreation (CE)	30
Total	920

(5) Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-88
Cost estimate of Dry Fork Creek Reservoir (H-31)

Item	Cost
Lands and damages	$116,000
Relocations	30,000
Reservoir clearing	2,000
Dam and appurtenant works	216,000
Fish and wildlife facilities	3,000
Access road	16,000
Recreation facilities	25,000
Buildings, grounds, and utilities	5,000
Permanent operating equipment	7,000
Engineering and design	76,000
Supervision and administration	34,000
Total	$530,000

SECTION V - DESCRIPTION OF ANGLER-USE SITES

34. ANGLER-USE SITES

The U. S. Fish and Wildlife Service recommended acquisition of small parcels of land, strategically located along open stream reaches between and below main stream and tributary stream reservoirs. These areas would serve as access and stopping-off points for float fishermen and hunters. Twenty-six angler-use sites, each having an area of approximately 7 acres, would be developed to satisfy requirements for sanitary facilities, drinking water, picnicking, and overnight camping. Nine of these areas would be accessible by boat only. At road access sites, parking lots and boat launching ramps would also be provided. The locations of these sites are shown on PLATE E-1, and pertinent data are contained in TABLE E-89. First costs are presented in detail in APPENDIX T.

TABLE E-89
Angler-use sites

Reservoir	Site designation	Location: Mile below damsite	Location: Name	Access	First cost
BIG RIVER SUB-BASIN					
#9 Irondale	A	8	Highway 8	Road	
	B	19	Terre Bleue Creek	Boat only	
	C	25	Highway E	Road	
	D	42	Washington Park	Road	$117,000
#2A Pine Ford	E	13	Morse Mill	Road	
	F	19	Island	Boat only	
	G	24	Cedar Hill	Road	
	H	35	Rockford Beach	Road	
	I	45	Meramec River Confluence	Boat only	134,000
MERAMEC RIVER SUB-BASIN					
#27 Salem	J	8	Wesco	Boat only	
	K	16	Benton Creek	Road	
	L	21	Highway 8	Road	
	M	30	1000 Oaks	Boat only	
	N	39	Idlewild	Road	
	O	44	Highway 19	Road	168,000
#40 Virginia Mines	P	9	Cove Church	Road	
	Q	11.5	Little Meramec River	Boat only	
	R	23	Robertsville	Road	84,000
I-14 Huzzah Creek	S	10	Huzzah	Boat only	
	T	19	Highway 8	Road	50,000
I-15A Courtois Creek	U	4	Highway 8	Road	
	V	16	Doss Branch	Boat only	50,000
BOURBEUSE RIVER SUB-BASIN					
#29 Union	W	10	Beuscher Creek	Road	
	X	19	Highway 50	Road	
	Y	28	Highway 66	Road	
	Z	34	Meramec River Confluence	Boat only	117,000
			Total		$720,000

SECTION VI - DESCRIPTION OF LOCAL PROTECTION PROJECTS

35. GENERAL

Between the mouth of the Meramec and Pacific, Missouri, at mile 49.0, nine areas were considered in detail for flood protection by the use of levees. The nine areas considered were designated areas Nos. 2, 4, 5, 7, 8, 9, 11, 12, and 17. See PLATE E-42 for location of these areas. See TABLE E-90 for pertinent data summary.

a. Design criteria. The nine areas selected for economic study were assigned levee grades to protect the areas from flooding by storms having either a 50-year or a 200-year frequency. Areas 2, 4, 5, and 17 were assigned 50-year frequencies; areas 7, 8, 9, 11, and 12 were assigned 200-year frequencies. Net levee grades were established 2 feet above the applicable frequency profile to provide freeboard. See PLATE E-43 for profiles.

b. Design details. Based on field reconnaissance and experience, the selected levee cross section consists of a 10-foot wide crown, 1 on 3 side slopes, revetment on riverside levee slopes in certain areas subject to current attack, and an 8-foot wide crushed stone road on the crown for inspection, maintenance, and access during flood emergencies. Closure structures and road crossings would be provided as required. Caving riverbanks in certain areas would also require grading and revetment. For the purpose of this report, revetment consists of a 24-inch thick blanket of stone protection. Landside berms were added wherever field reconnaissance indicated that berms might be needed for underseepage purposes. Seepage relief wells were also included at pumping stations and in certain areas where the need appeared likely.

c. Estimates of levee costs. Estimates of first cost for the levees in the lower part of the Meramec Basin are based on the assumption that the United States will clear the right-of-way; construct the levees, floodwalls, pumping stations, closure structures, railroad relocations, revetments, and maintenance roads; excavate the ponding areas; provide drainage structures; and seed the embankments. Local interests will furnish all lands, easements, and rights-of-way; relocate all facilities with the exception of railroad relocations as may be required; accomplish the required interior drainage; hold and save the United States free from damage due to the construction works; and maintain the project after completion. Total first costs are presented in detail in APPENDIX T. Estimates are based on July 1963 price levels.

36. TELEGRAPH ROAD (AREA NO. 2)

a. Location. This area is located on the left bank of the Meramec River in St. Louis County between river miles 1.7 and 3.4. St. Louis County Highway VV crosses the area.

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MERAMEC RIVER, MISSOURI COMPREHENSIVE BASIN STUDY. VOLUME V. AP--ETC(U)
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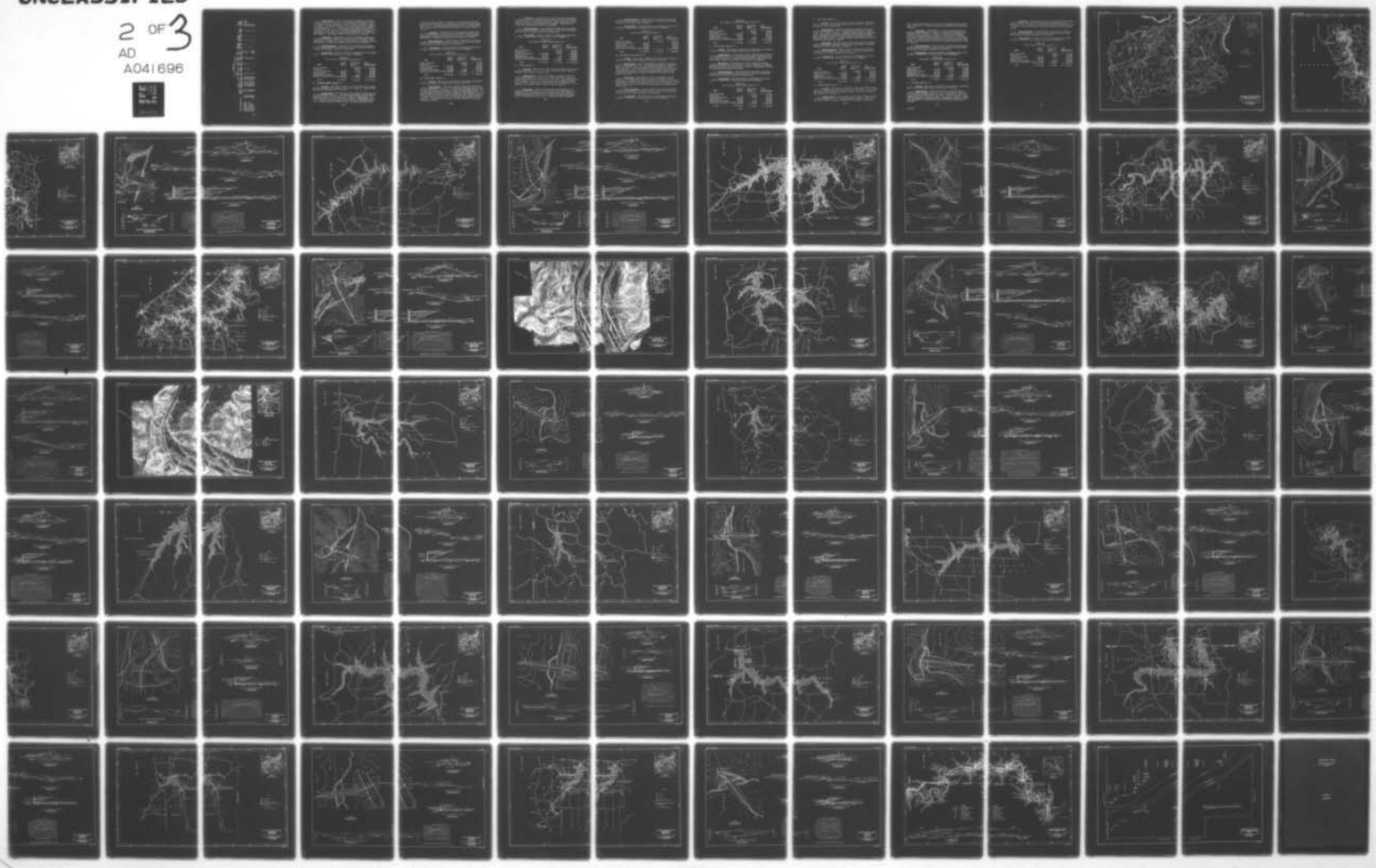


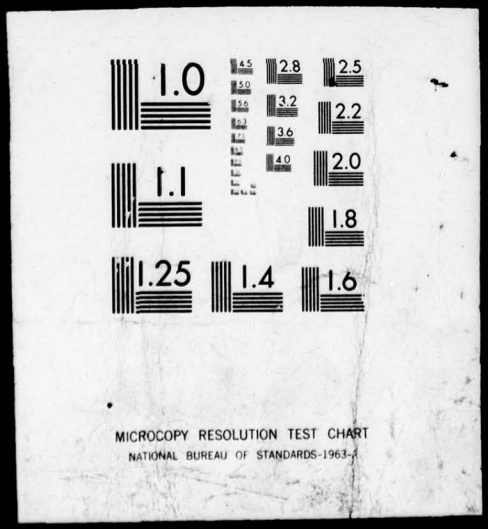


TABLE E-90
Pertinent data, local protection

Name and number of area		Land protected (acres)	Selected degree of protection (frequency)	Length of levee (feet)	Average height of levee (feet)	Floodwall length (feet)	Average ht. of floodwall (feet)	Embankment right-of-way (acres)	Riverbank revetment (lin.ft.)	Closure Structures		Bridges		Pumping stations	Pumping station capacity (c.f.s.)
										Highway	Railroad	Highway	Railroad		
Telegraph Road	(#2)	325	50-year	11,300	23	--	--	45	5,500	1	--	--	--	2	432 & 120
Starling Airport	(#4)	610	50-year	14,400	18	130	18	49	--	--	1	--	--	2	205 & 696
Butler Lakes	(#5)	1,110	50-year	31,300	14	--	--	93	16,000	--	--	--	--	2	654 & 155
Fenton	(#7)	70	200-year	8,300	10	1,500	4	22	--	2	--	--	--	1	411
West Watson Road	(#8)	380	200-year	14,500	9	--	--	32	--	--	--	1	--	1	188
Weiss Airport	(#9)	620	200-year	22,600	9	--	--	50	--	--	--	--	--	1	684
Valley Park	(#11)	500	200-year	17,400	10	--	--	46	1,000	1	1	--	--	1	211
Peerless Park	(#12)	920	200-year	23,700	10	--	--	62	9,000	--	--	1	1	1	474
Fox Creek	(#17)	760	50-year	8,000	11	--	--	14	1,500	--	--	1	--	1	624

b. Design details. The levee will have a length of 11,300 feet and an average height of 23 feet. The embankment for Highway VV creates two separate interior drainage areas, each of which will require a pumping station. The pumping station in the north area would have a capacity of approximately 432 c.f.s. and the south station would have a capacity of approximately 120 c.f.s. Ponding would be provided in order to reduce pump sizes. About 7,000 feet of interior ditching would be required. Approximately 5,500 feet of caving riverbank would have to be stabilized with revetment. One highway closure structure would be required.

c. Relocations. Approximately 0.5 mile of existing crushed-stone road would have to be relocated to preserve access to clubhouses. Minor alterations to telephone and electric service lines would also be required. Approximately 12 houses and clubhouses would have to be relocated.

d. Land requirements. About 150 acres of land would be required, of which 45 acres would be rights-of-way, 80 acres for borrow areas, and 25 acres for ditching, ponding, and relocations.

e. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-91
Cost estimate of Telegraph Road (Area No. 2)

Item	Federal costs	Non-Federal costs	Total project costs
Lands and damages	-	$ 200,000	$ 200,000
Relocations	-	19,000	19,000
Levees and floodwalls	$ 980,000	11,000	991,000
Pumping plants	900,000	-	900,000
Engineering and design	240,000	4,000	244,000
Supervision and administration	160,000	3,000	163,000
Total	$ 2,280,000	$ 237,000	$ 2,517,000

37. STARLING AIRPORT (AREA NO. 4)

a. Location. This area is located on the right bank of the Meramec River in Jefferson County between river miles 3.4 and 6.0. The St. Louis-San Francisco Railroad crosses the area.

b. Design details. The levee will have a length of 14,400 feet and an average height of 18 feet. Two pumping stations have been provided in this study because of the nature of the existing drainage pattern. The pumping station in the north would have a capacity of approximately 205 c.f.s., and the south station would have a capacity of approximately 696 c.f.s. Ponding would be provided in order to reduce pump sizes. About

8,000 feet of ditching would be required. A floodwall about 130 feet long and 18 feet high would be required where the levee alinement passes through the St. Louis-San Francisco Railroad trestle at the north crossing. A small closure structure would be needed at the south railroad crossing.

c. Relocations. Approximately 1 mile of bituminous road would have to be relocated to preserve access to clubhouses. Numerous minor alterations to telephone and electric service lines would be required. Approximately 32 houses and clubhouses would have to be relocated.

d. Land requirements. About 124 acres of land would be required, of which 49 acres would be for rights-of-way, 45 acres for borrow areas, and 30 acres for ditching, ponding, and relocation.

e. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-92
Cost estimate of Starling Airport (Area No. 4)

Item	Federal costs	Non-Federal costs	Total project costs
Lands and damages	-	$ 265,000	$ 265,000
Relocations	-	86,000	86,000
Levees and floodwalls	$ 699,000	7,000	706,000
Pumping plants	1,239,000	-	1,239,000
Engineering and design	248,000	12,000	260,000
Supervision and administration	164,000	8,000	172,000
Total	$ 2,350,000	$ 378,000	$ 2,728,000

38. BUTLER LAKES (AREA NO. 5)

a. Location. This area is located on the left bank of the Meramec River in St. Louis County between river miles 6.9 and 12.5.

b. Design details. The levee would have a length of 31,300 feet and an average height of 14 feet. Two pumping stations have been provided in this study because of the nature of the existing drainage pattern. The upstream pumping station would have a capacity of approximately 654 c.f.s., and the downstream station would have a capacity of approximately 155 c.f.s. Ponding would be provided in order to reduce pump size. About 10,000 feet of interior ditching and 2,500 feet of exterior creek diversion would be required. About 16,000 feet of caving riverbank would have to be stabilized with revetment.

c. Relocations. Approximately 0.4 mile of existing crushed-stone road and 0.2 mile of bituminous surfaced road would have to be relocated to preserve access to houses and clubhouses. Minor alterations to telephone and electric service lines would be required. Approximately 15 houses and clubhouses would have to be relocated.

d. Land requirements. About 182 acres of land would be required, of which 93 acres would be for rights-of-way, 72 acres for borrow areas, and 17 acres for ditching, ponding, and relocations.

e. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-93
Cost estimate of Butler Lakes (Area No. 5)

Item	Federal costs	Non-Federal costs	Total project costs
Lands and damages	-	$ 286,000	$ 286,000
Relocations	-	34,000	34,000
Levees and floodwalls	$ 1,528,000	10,000	1,538,000
Pumping plants	1,142,000	-	1,142,000
Engineering and design	339,000	5,000	344,000
Supervision and administration	221,000	4,000	225,000
Total	$ 3,230,000	$ 339,000	$ 3,569,000

39. FENTON (AREA NO. 7)

a. Location. This area is located along Fenton Creek which empties into the Meramec River at mile 15.0. The levee and floodwall would be located on the left bank of Fenton Creek.

b. Design details. The levee would have a length of 8,300 feet and an average height of 10 feet. The floodwall would have a length of 1,500 feet and would vary in height from 3 to 7 feet. One pumping station having a capacity of 411 c.f.s. would be required. Ponding area would not be provided. Approximately 1,000 feet of interior ditching would be required. Two highway closure structures would be required.

c. Relocations. The levee would require the relocation of 14 houses and one store building. Nine additional houses would have to be relocated or suffer damages because the levee would occupy backyards. A public swimming pool would have to be removed. Numerous minor alterations to telephone and electric service lines would also be required.

d. Land requirements. About 40 acres of land would be required, of which 22 acres would be for rights-of-way, 16 acres for borrow areas, and 2 acres for ditching and relocations.

e. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-94
Cost estimate of Fenton (Area No. 7)

Item	Federal costs	Non-Federal costs	Total project costs
Lands and damages	-	$ 674,000	$ 674,000
Levees and floodwalls	$ 402,000	-	402,000
Pumping plant	602,000	-	602,000
Engineering and design	128,000	-	128,000
Supervision and administration	88,000	-	88,000
Total	$ 1,220,000	$ 674,000	$ 1,894,000

40. WEST WATSON ROAD (AREA NO. 8)

a. Location. This area is located on the left bank of the Meramec River in St. Louis County between river miles 15.8 and 17.0.

b. Design details. The levee would have a length of 14,500 feet and an average height of 9 feet. One pumping station with a capacity of 188 c.f.s. would be required. Ponding would be provided in order to reduce pump sizes. About 4,000 feet of interior ditching and an exterior creek diversion of about 5,500 feet would be required. Under present conditions, the embankment of Missouri Highway 30 would serve as the levee for 600 feet.

c. Relocations. Approximately 0.6 mile of crushed-stone road would have to be relocated to preserve access to clubhouses. Minor alterations to telephone and electric service lines would also be required. Approximately 15 houses and clubhouses would have to be relocated. A new highway bridge would be required on West Watson Road to maintain access into the area.

d. Land requirements. About 57 acres of land would be required, of which 32 acres would be for rights-of-way, 15 acres for borrow areas, and 10 acres for ditching, ponding, and relocations.

e. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-95
Cost estimate of West Watson Road (Area No. 8)

Item	Federal costs	Non-Federal costs	Total project costs
Lands and damages	-	$ 108,000	$ 108,000
Relocations	-	68,000	68,000
Levees and floodwalls	$ 203,000	2,000	205,000
Pumping plant	373,000	-	373,000
Engineering and design	73,000	9,000	82,000
Supervision and administration	49,000	6,000	55,000
Total	$ 698,000	$ 193,000	891,000

41. WEISS AIRPORT (AREA NO. 9)

a. Location. This area is located on the right bank of the Meramec River in St. Louis County between river miles 16.4 and 20.3.

b. Design details. The levee will have a length of 22,600 feet and an average height of 9 feet. One pumping station with a capacity of 684 c.f.s. would be required. Ponding would be provided to reduce pump sizes. Approximately 9,000 feet of interior ditching would be necessary.

c. Relocations. Approximately 0.5 mile of existing bituminous surfaced road would have to be relocated. Minor alterations to telephone and electric service lines would also be required. Approximately 20 houses and clubhouses would require relocation.

d. Land requirements. About 100 acres of land would be required, of which 50 acres would be for rights-of-way, 26 acres for borrow areas, and 24 acres for ditching, ponding, and relocations.

e. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-96
Cost estimate of Weiss Airport (Area No. 9)

Item	Federal costs	Non-Federal costs	Total project costs
Lands and damages	-	$ 165,000	$ 165,000
Relocations	-	41,000	41,000
Levees and floodwalls	$ 337,000	4,000	341,000
Pumping plant	844,000	-	844,000
Engineering and design	151,000	6,000	157,000
Supervision and administration	98,000	4,000	102,000
Total	$ 1,430,000	$ 220,000	$ 1,650,000

42. VALLEY PARK (AREA NO. 11)

a. Location. This area is located on the left bank of the Meramec River in St. Louis County between river miles 20.8 and 22.3. The area contains the town of Valley Park.

b. Design details. The levee would have a length of 17,400 feet and an average height of 10 feet. One pumping station having a capacity of 211 c.f.s. would be required. Ponding would be provided to reduce pump sizes. Approximately 2,000 feet of interior ditching would be required. About 1,000 feet of revetment would be required on the banks of Grand Glaize and Fishpot Creeks. One highway closure structure and one railroad closure structure would be required.

c. Relocations. The levee would require the relocation of approximately 23 houses and clubhouses. Numerous minor alterations to telephone and electric service lines would be required.

d. Land requirements. About 87 acres of land would be required, of which 46 acres would be for rights-of-way, 35 acres for borrow areas, and 6 acres for ditching, ponding, and relocations.

e. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-97
Cost estimate of Valley Park (Area No. 11)

Item	Federal costs	Non-Federal costs	Total project costs
Lands and damages	-	$ 282,000	$ 282,000
Levees and floodwalls	$ 723,000	4,000	727,000
Pumping plant	393,000	-	393,000
Engineering and design	141,000	1,000	142,000
Supervision and administration	93,000	2,000	95,000
Total	$ 1,350,000	$ 289,000	$ 1,639,000

43. PEERLESS PARK (AREA NO. 12)

a. Location. This area is located on the right bank of the Meramec River in St. Louis County between river miles 21.3 and 24.1. The St. Louis-San Francisco Railroad passes through the area. The village of Peerless Park is located in the area.

b. Design details. The levee will have a length of 23,700 feet and an average height of 10 feet. One pumping station having a capacity of 474 c.f.s. would be required. Ponding will be provided to reduce pump

sizes. Approximately 8,000 feet of interior ditching would be required. About 9,000 feet of riverbank revetment would be needed to stabilize the riverbank.

c. Relocations. Approximately 1.5 miles of crushed-stone road would have to be relocated. Relocation of approximately 18 houses and clubhouses would be required. A portion of Peerless Park playground and picnic area would require relocation. The diversion of Williams Creek behind a back levee would require the construction of a new bridge for the St. Louis-San Francisco Railroad and a new road bridge for local traffic. Minor alterations to electric and telephone service lines would be required.

d. Land requirements. About 136 acres of land would be required, of which 62 acres would be for rights-of-way, 49 acres for borrow areas, and 25 acres for ditching, ponding, and relocations.

e. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

TABLE E-98
Cost estimate of Peerless Park (Area No. 12)

Item	Federal costs	Non-Federal costs	Total project costs
Lands and damages	-	$ 201,000	$ 201,000
Relocations	$ 284,000	143,000	427,000
Levees and floodwalls	741,000	4,000	745,000
Pumping plant	559,000	-	559,000
Engineering and design	200,000	23,000	223,000
Supervision and administration	126,000	12,000	138,000
Total	$ 1,910,000	$ 383,000	$ 2,293,000

43. FOX CREEK (AREA NO. 17)

a. Location. This area is located on the left bank of the Meramec River in St. Louis County between river miles 45.2 and 46.5.

b. Design details. Two levees will have a combined length of 8,000 feet and an average height of 11 feet. Approximately 7,500 feet of creek channel excavation would be required to divert Fox Creek. One pumping station with a capacity of 624 c.f.s. would be required. Ponding would be provided to reduce pump sizes. Approximately 1,500 feet of Fox Creek upstream of the diversion area would require stabilization with revetment.

c. Relocations. Approximately 0.2 mile of existing private crushed-stone road and 0.7 mile of public crushed-stone road would have to be relocated. Minor alterations to electric and telephone service lines would be required. One new bridge would be required across Fox Creek diversion channel.

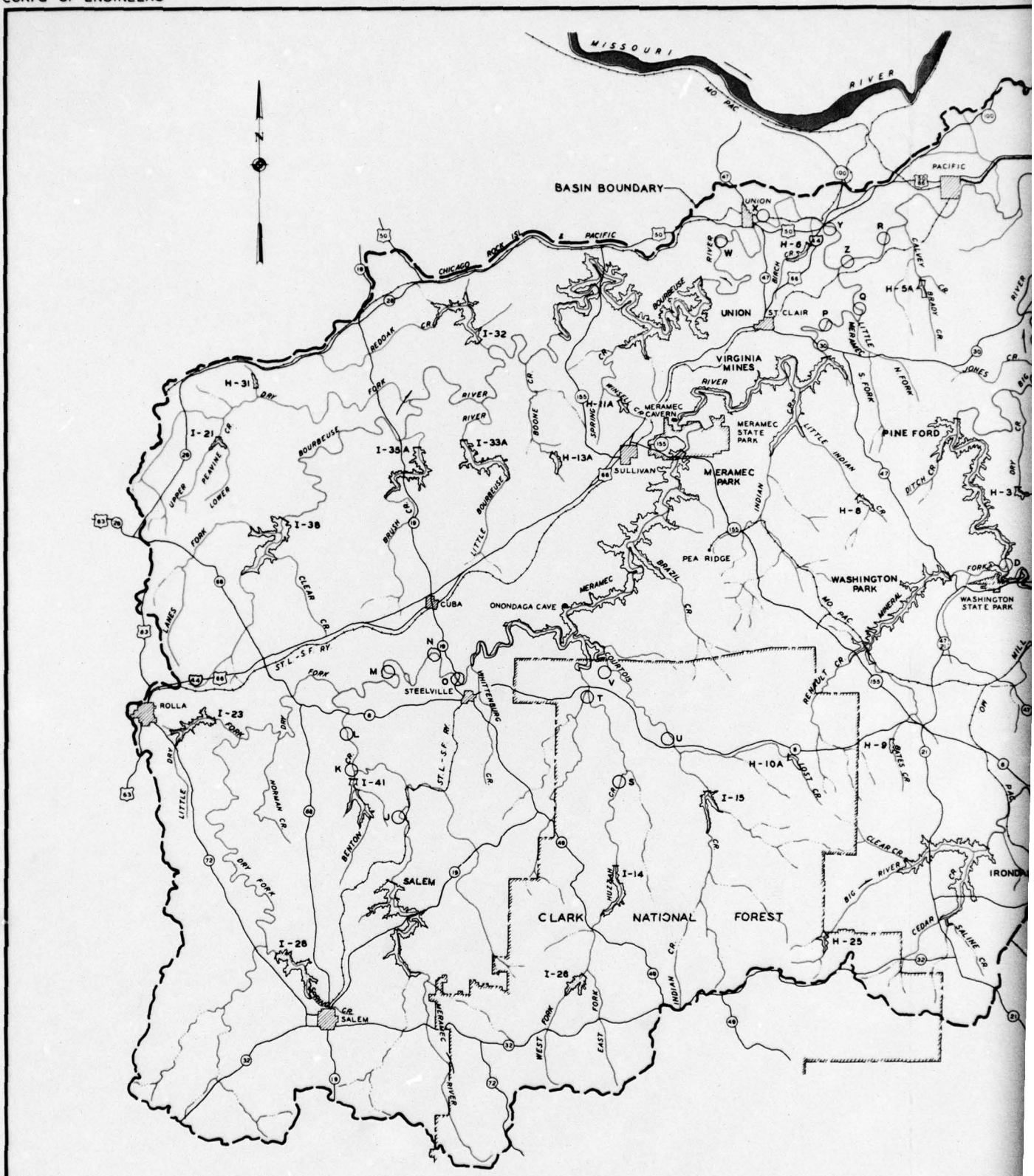
d. Land requirements. About 78 acres of land would be required, of which 14 acres would be for rights-of-way, 22 acres for borrow areas, and 42 acres for ditching, ponding, and relocations.

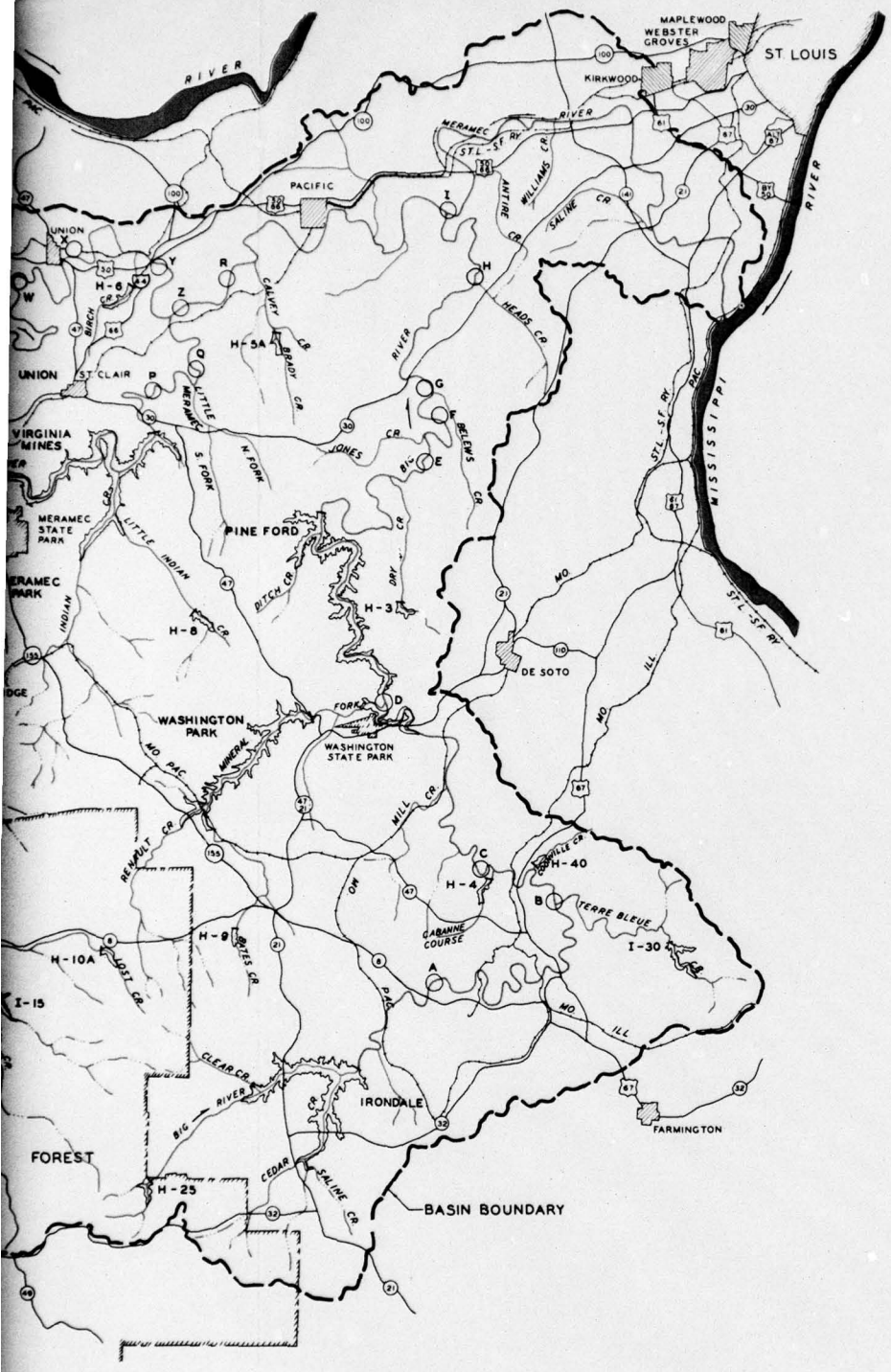
e. Cost estimate. The cost estimate is summarized in the following table. Detailed cost estimates may be found in APPENDIX T.

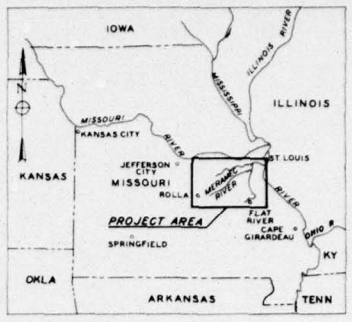
TABLE E-99
Cost estimate of Fox Creek (Area No. 17)

Item	Federal costs	Non-Federal costs	Total project costs
Lands and damages	-	$ 46,000	$ 46,000
Relocations	-	129,000	129,000
Levees and floodwalls	$ 289,000	5,000	294,000
Pumping plant	781,000	-	781,000
Engineering and design	137,000	17,000	154,000
Supervision and administration	93,000	10,000	103,000
Total	$ 1,300,000	$ 207,000	$ 1,507,000

CORPS OF ENGINEERS







VICINITY MAP
SCALE IN MILES
50 0 50 100

LEGEND

RESERVOIRS

ANGLER-USE SITES

NOTE: RESERVOIR LIMITS SHOWN ARE AT NORMAL POOL ELEVATION.

MERAMEC RIVER BASIN, MISSOURI
RESERVOIRS AND ANGLER-USE SITES SELECTED FOR STUDY

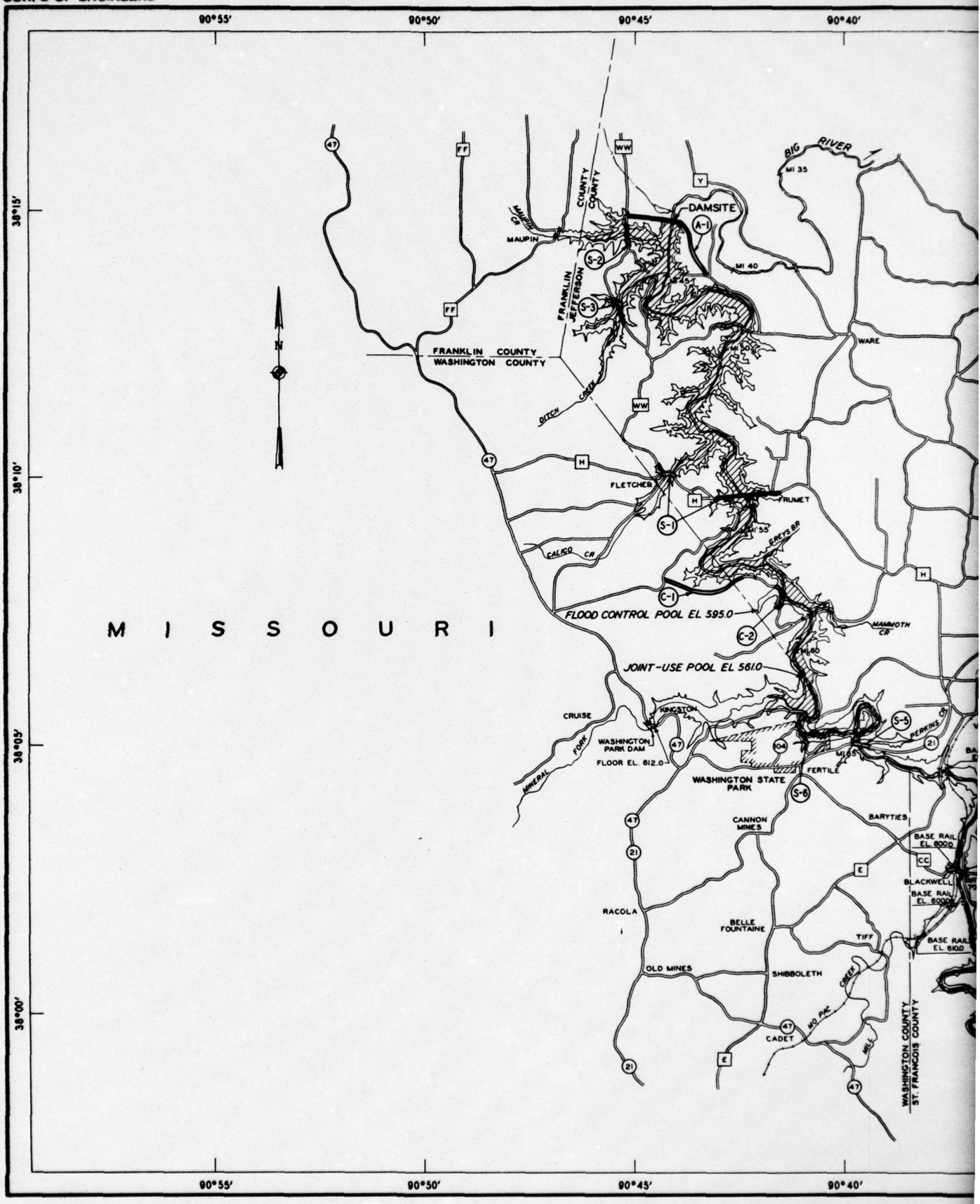
IN 1 SHEET SHEET NO. 1

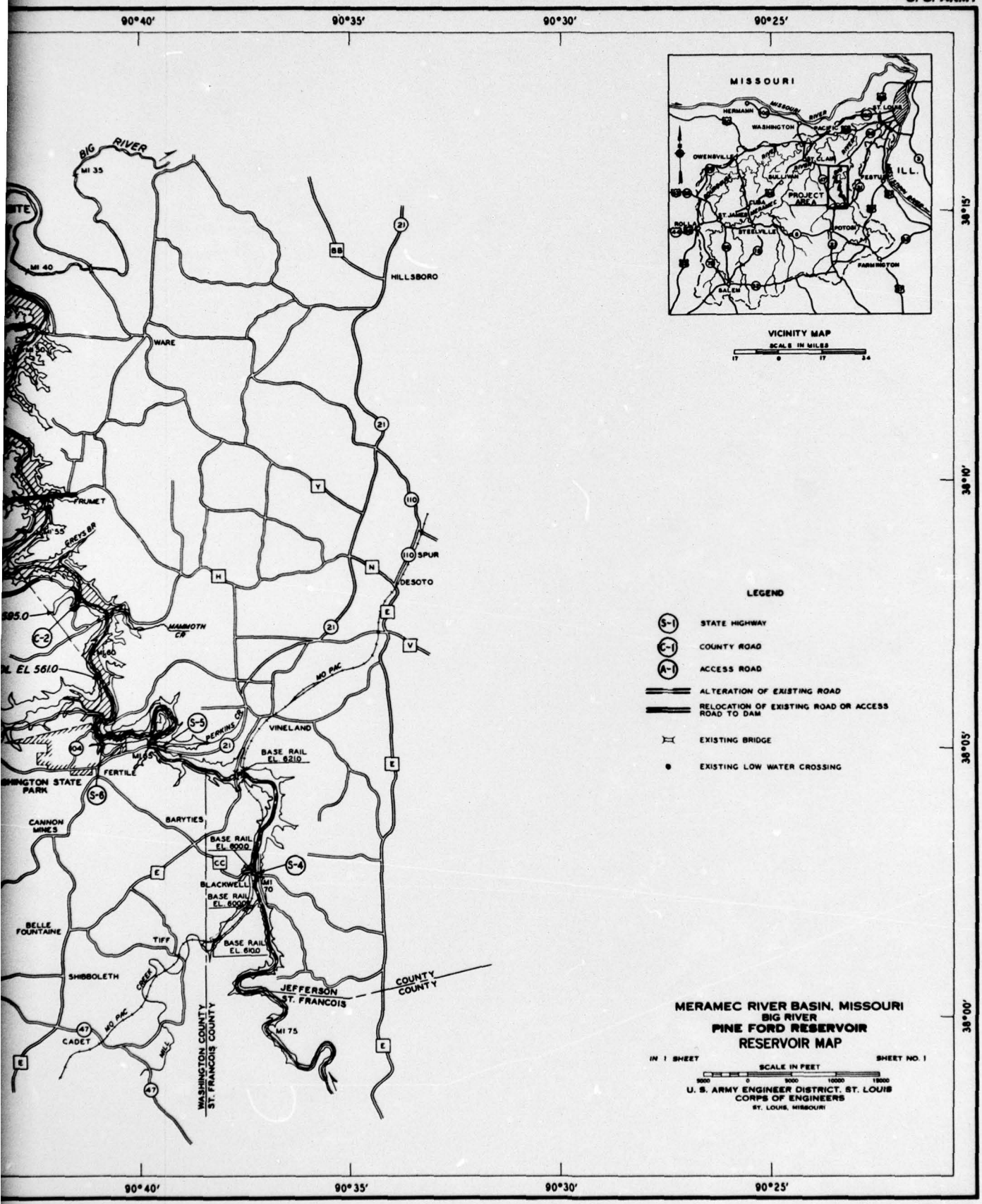
SCALE IN MILES
5 0 5 10

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-1

CORPS OF ENGINEERS





MERAMEC RIVER BASIN, MISSOURI
BIG RIVER
PINE FORD RESERVOIR
RESERVOIR MAP

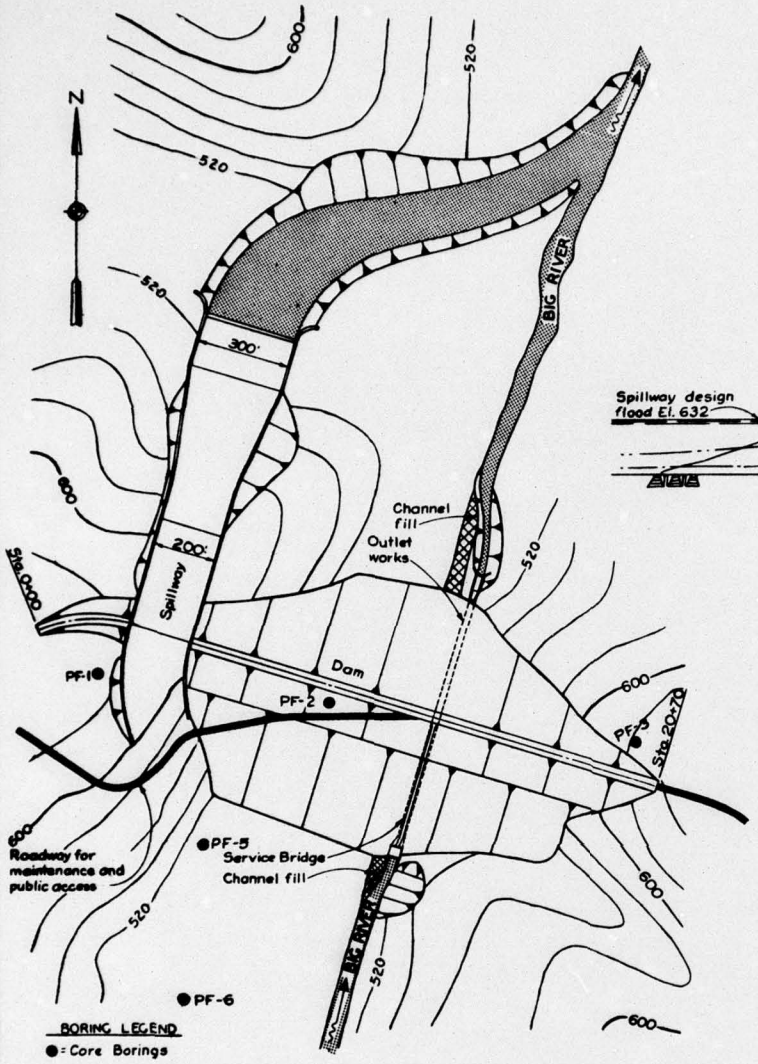
IN 1 SHEET SHEET NO. 1

SCALE IN FEET
5000 0 5000 10000 15000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-2

CORPS OF ENGINEERS



PLAN

PF-7 ●

SCALE IN FEET
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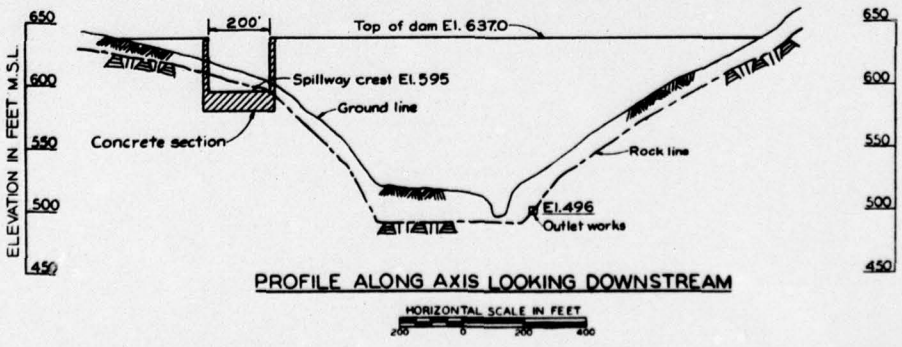
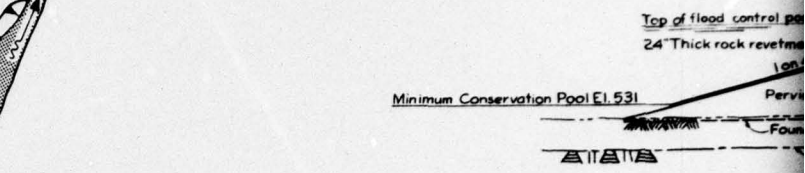
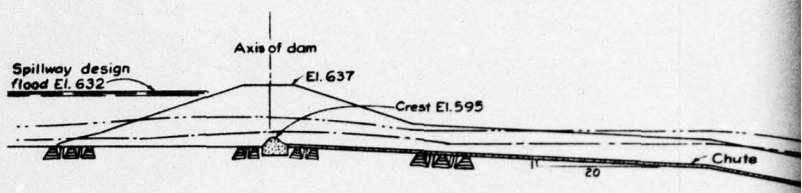
CONTOUR INTERVAL 20 FEET



PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONTAL SCALE IN FEET
200 0 200 400





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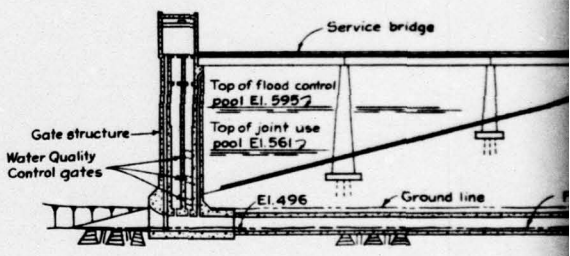

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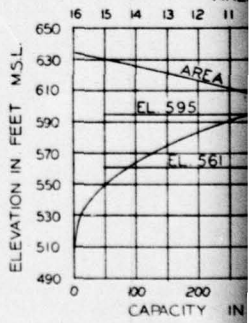
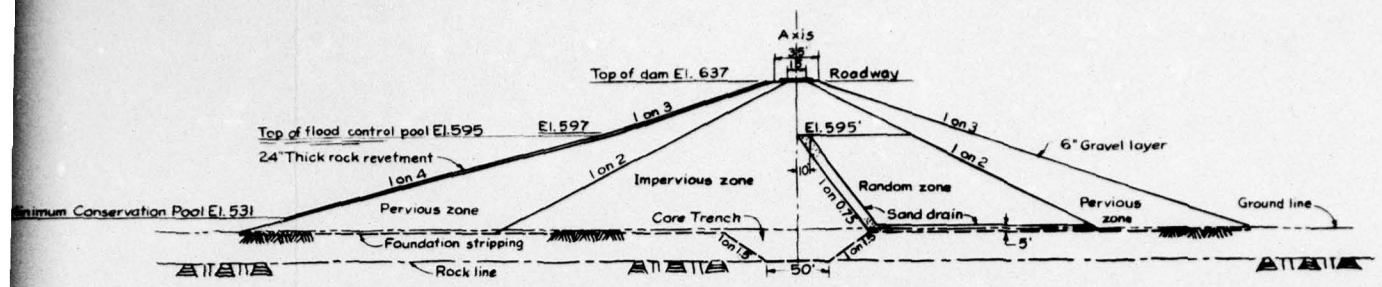


RESERVOIR A

U. S. ARMY



TYPICAL SECTION OF DAM

SCALE IN FEET
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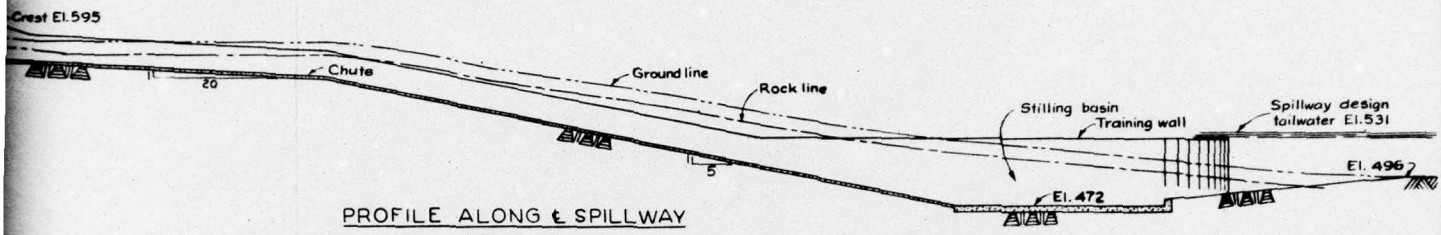

PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET
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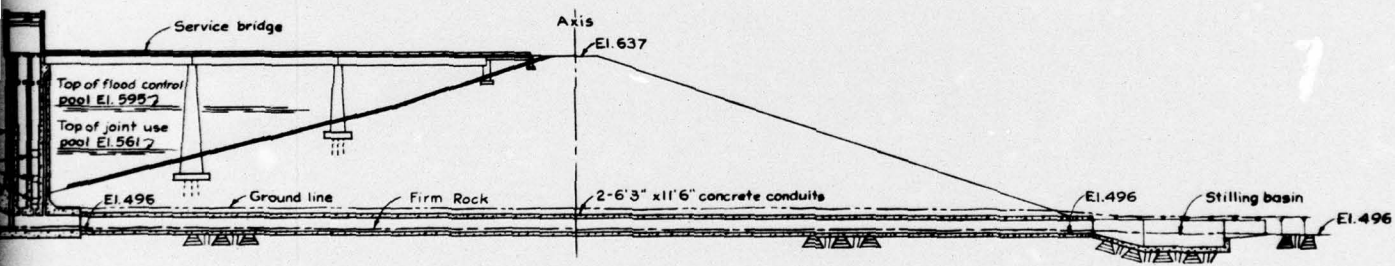

SECTION THRU OUTLET WORKS

SCALE IN FEET
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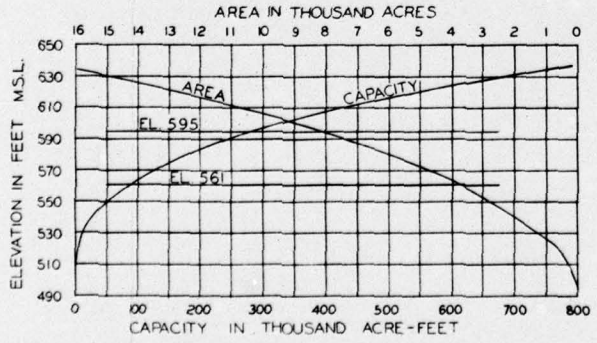


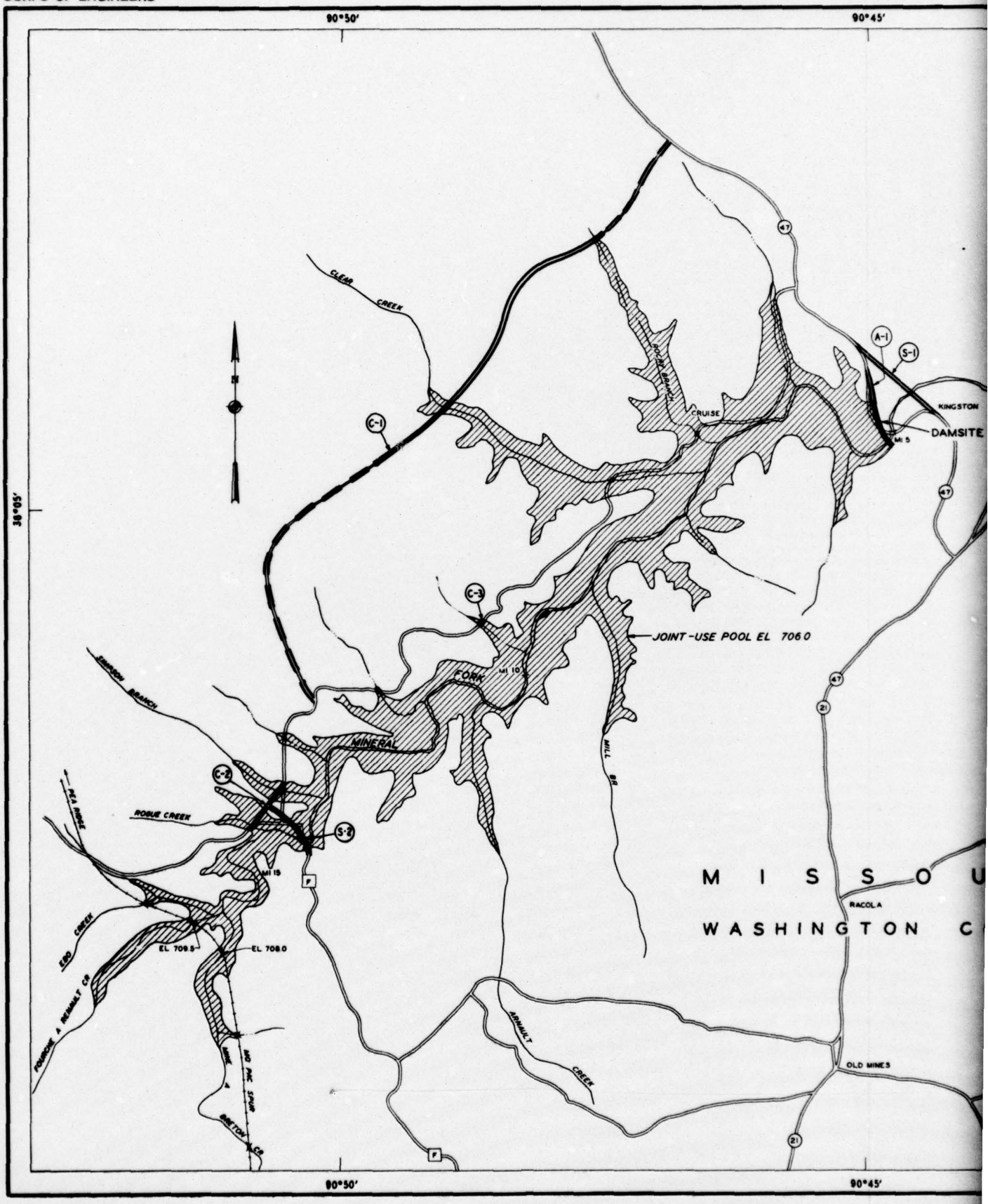
RESERVOIR AREA AND CAPACITY CURVES

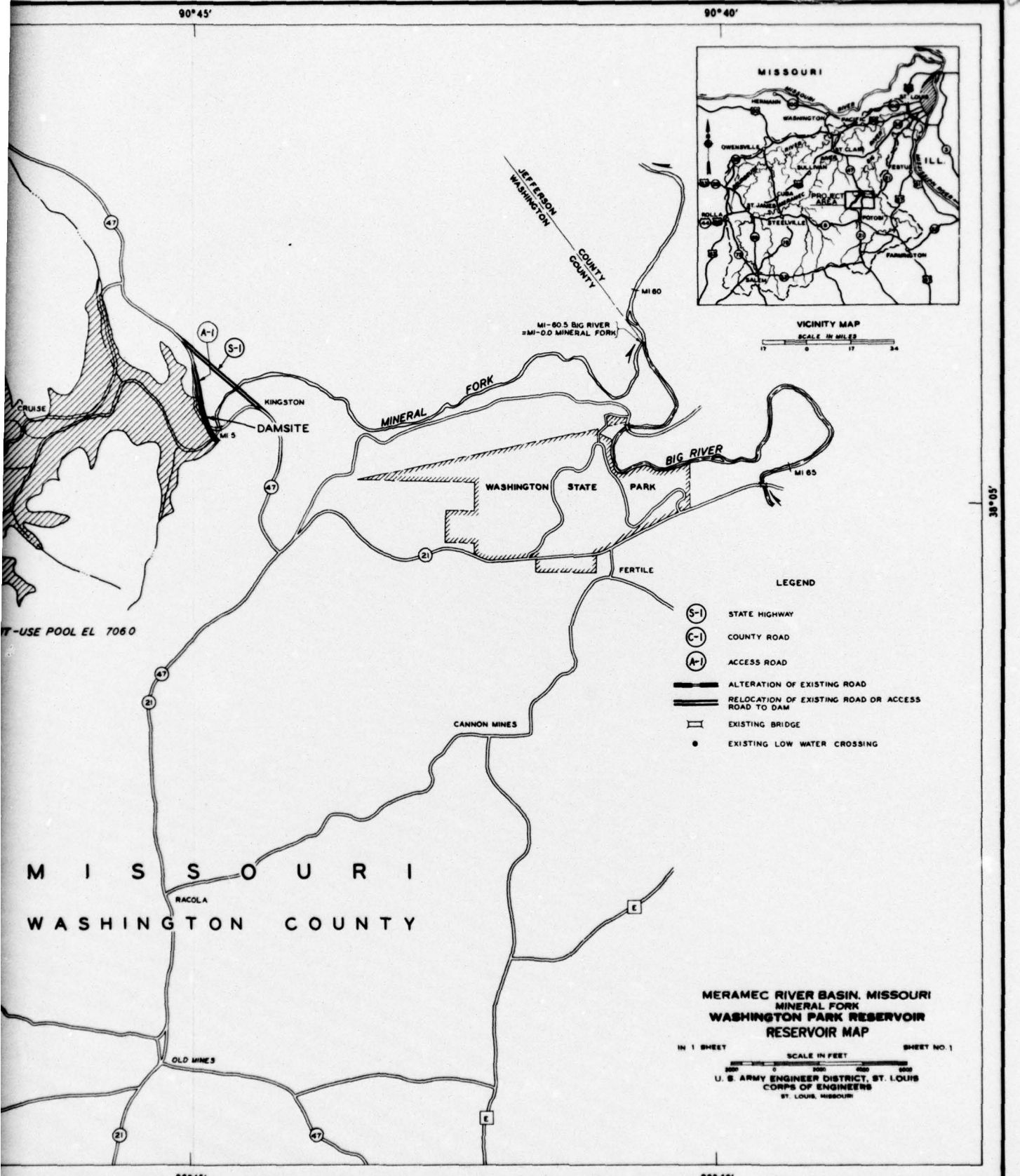
MERAMEC RIVER BASIN, MISSOURI
BIG RIVER
PINE FORD DAM
DESIGN DETAILS

IN 1 SHEET SHEET NO. 1
SCALE AS SHOWN
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-3

CORPS OF ENGINEERS





MERAMEC RIVER BASIN, MISSOURI
MINERAL FORK
WASHINGTON PARK RESERVOIR
RESERVOIR MAP

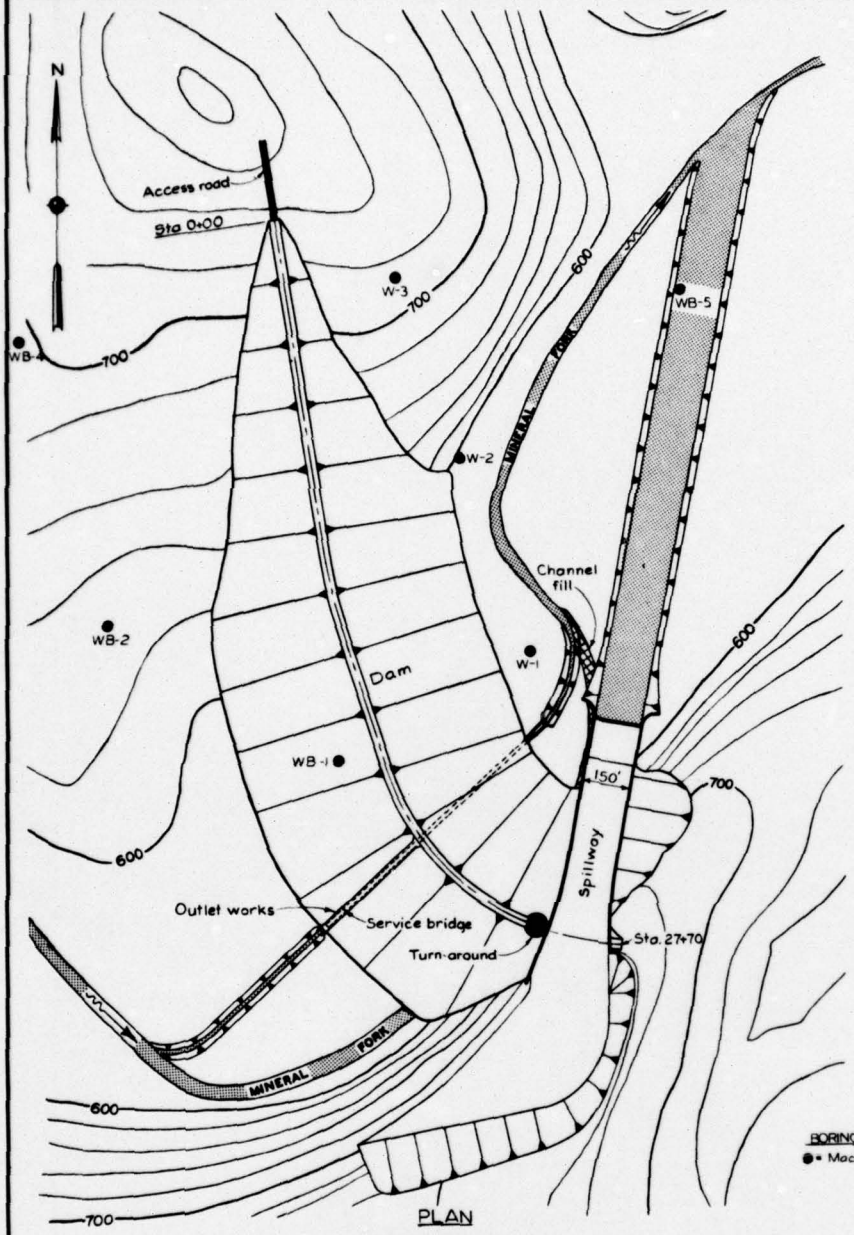
IN 1 SHEET — SHEET NO. 1

SCALE IN FEET
2000 0 2000 4000 6000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-4

CORPS OF ENGINEERS



PLAN

SCALE IN FEET
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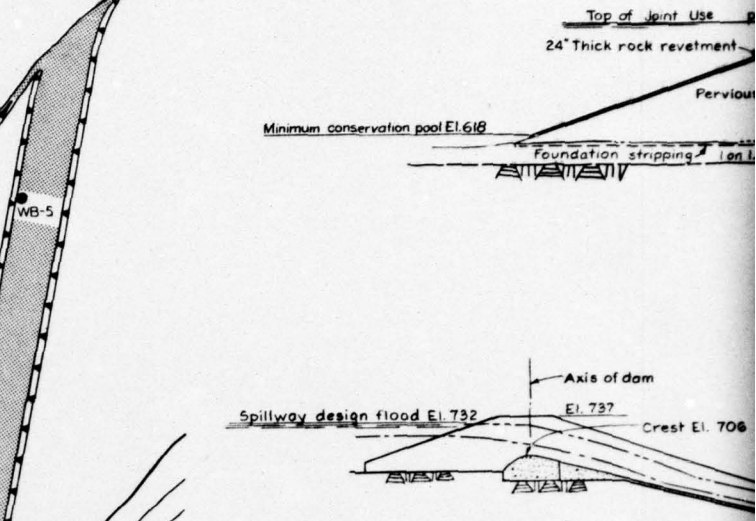
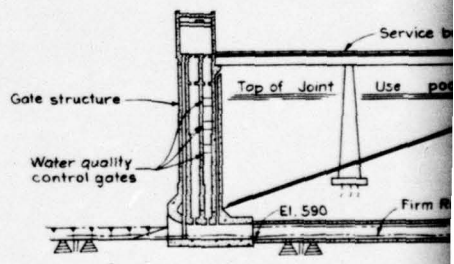
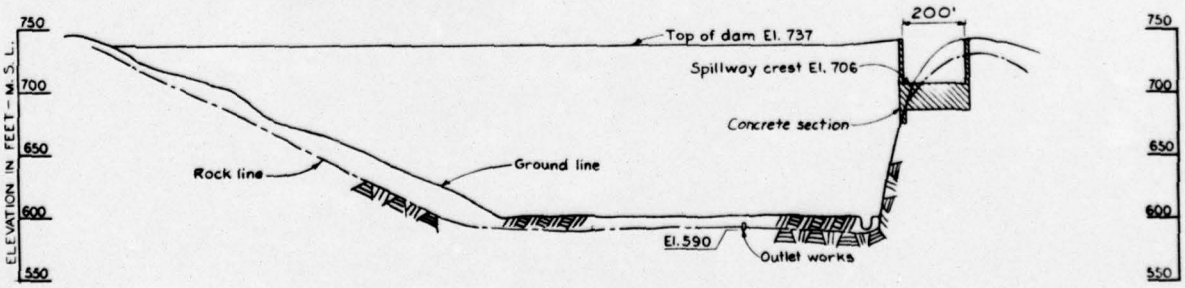
CONTOUR INTERVAL 20 FEET

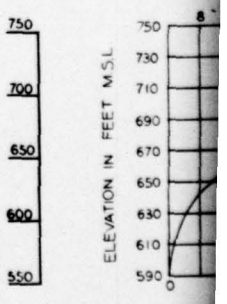


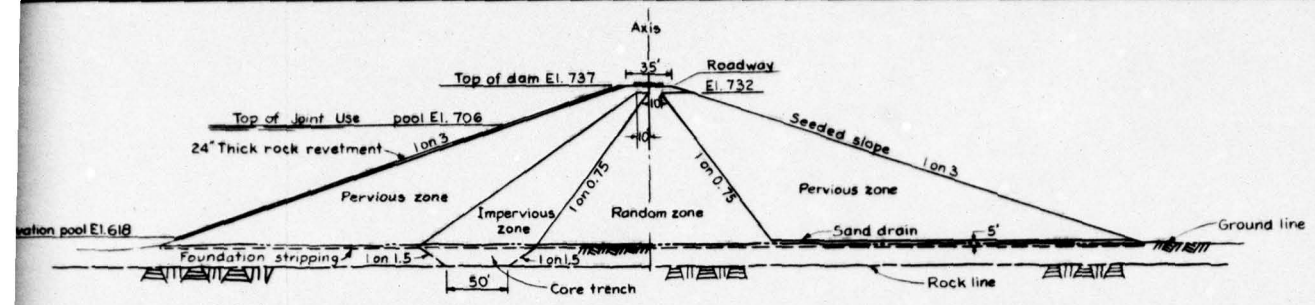




PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONTAL SCALE IN FEET
200 0 200 400





TYPICAL SECTION OF DAM

SCALE IN FEET
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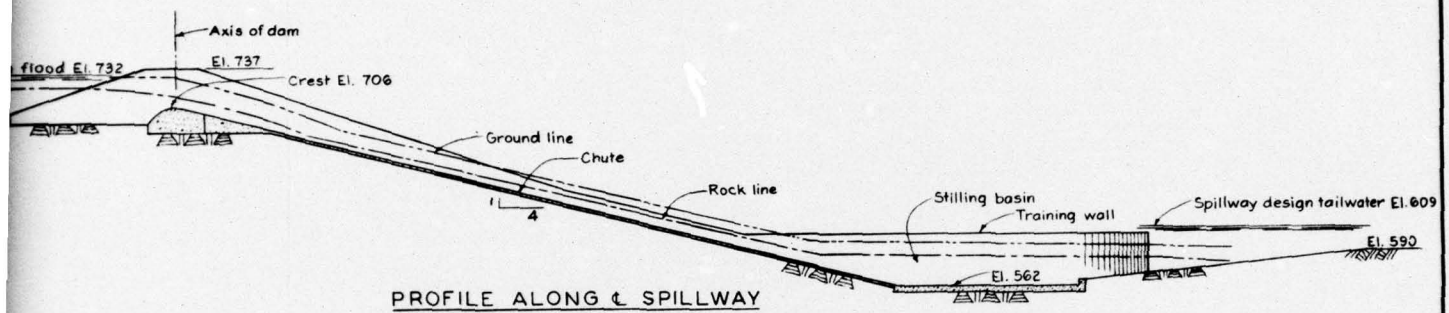

PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET
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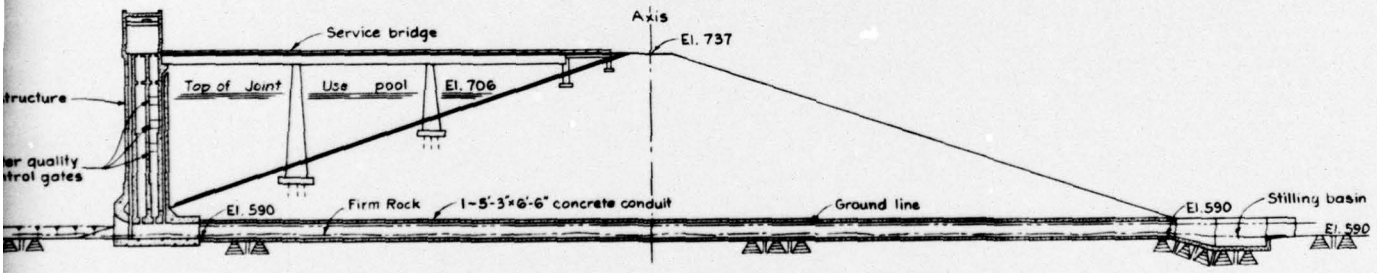

SECTION THRU OUTLET WORKS

SCALE IN FEET
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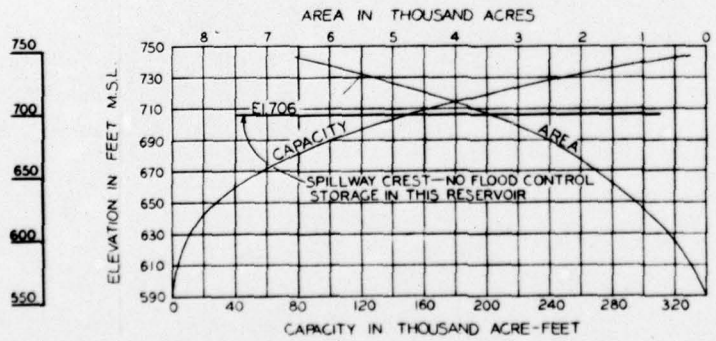


RESERVOIR AREA AND CAPACITY CURVES

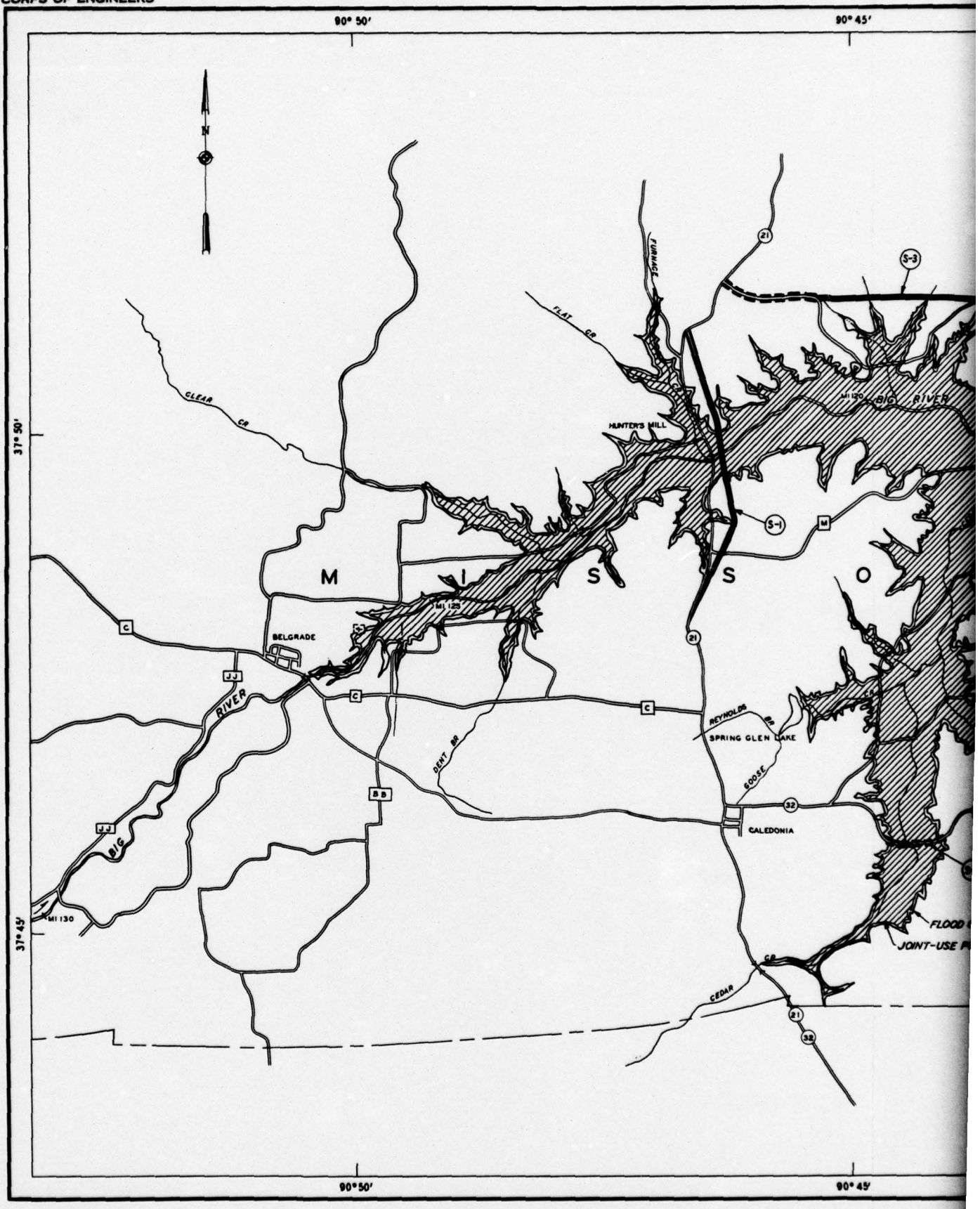
MERAMEC RIVER BASIN, MISSOURI
MINERAL FORK
WASHINGTON PARK DAM
DESIGN DETAILS

IN 1 SHEET ENGRY NO. 1
SCALE AS SHOWN

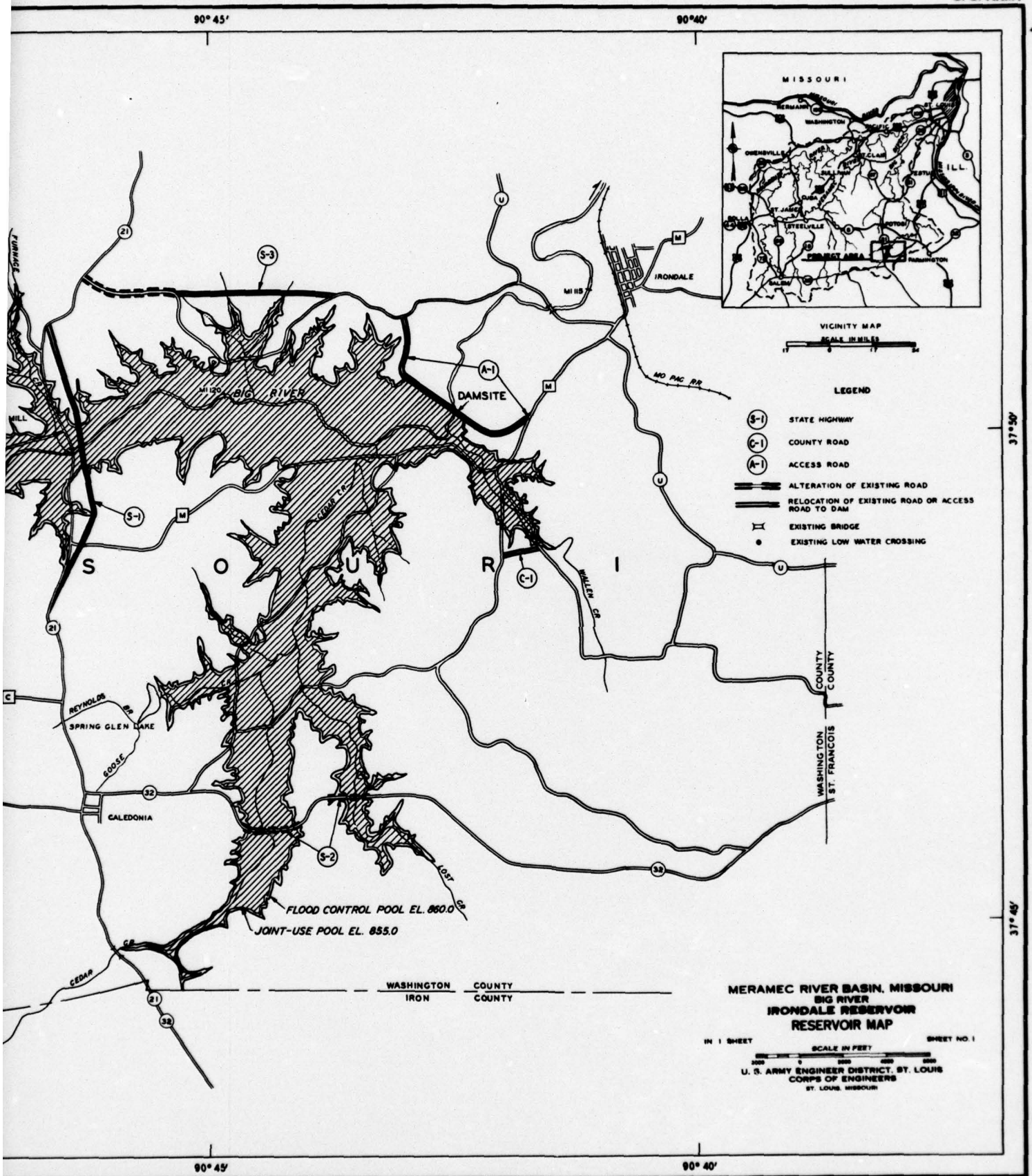
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS MISSOURI

PLATE E-5

CORPS OF ENGINEERS



U. S. ARMY



MERAMEC RIVER BASIN, MISSOURI
BIG RIVER
IRONDALE RESERVOIR
RESERVOIR MAP

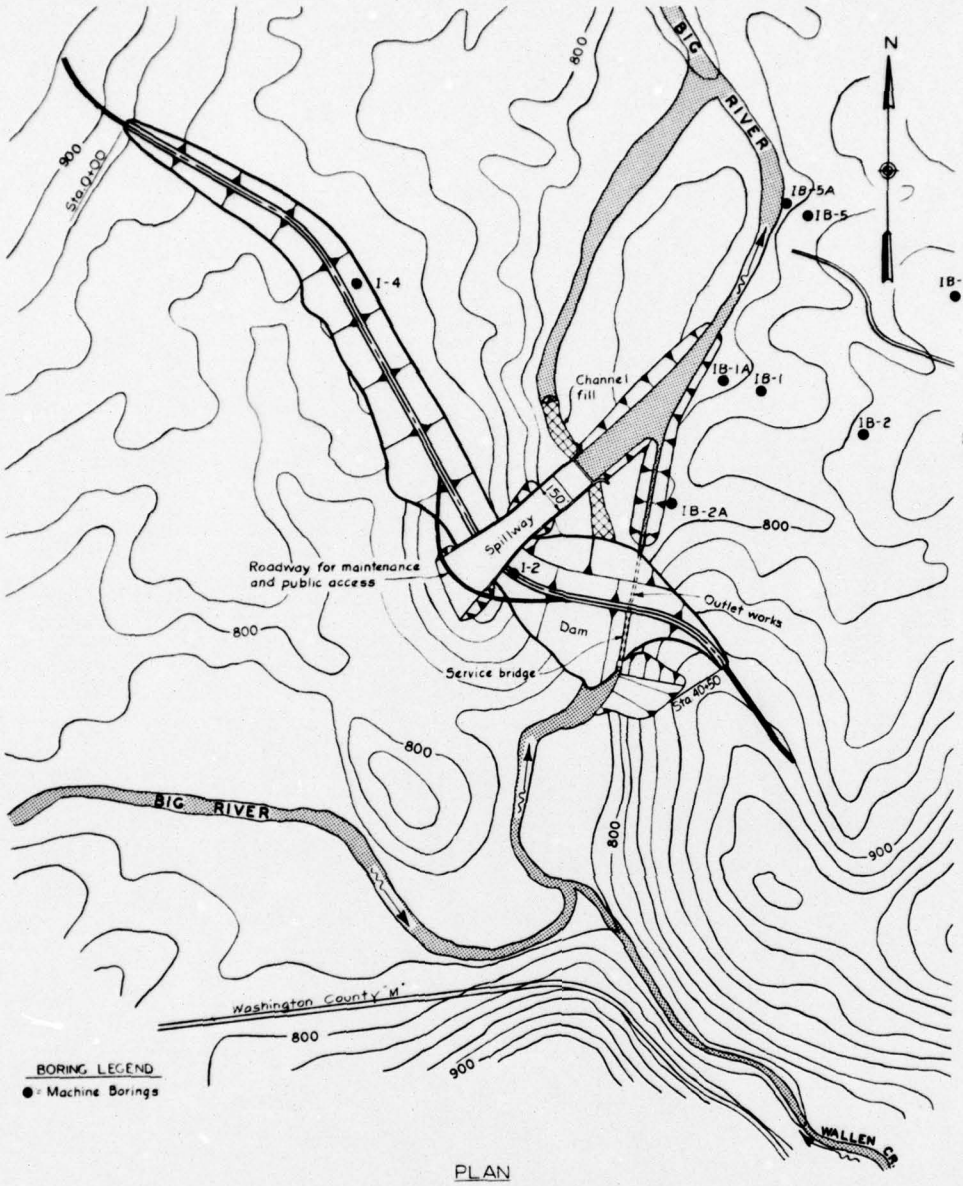
IN 1 SHEET SHEET NO. 1

SCALE IN FEET

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-6

CORPS OF ENGINEERS

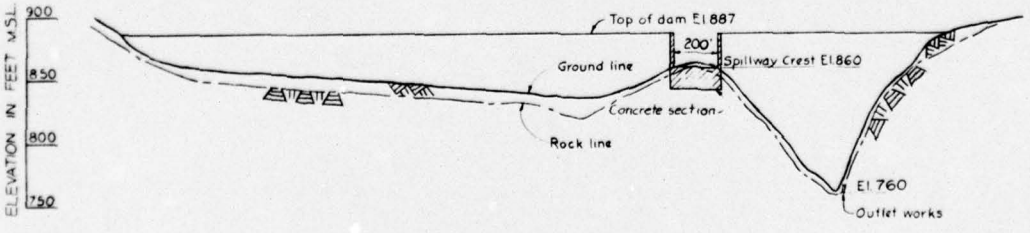


PLAN

SCALE IN FEET

300 0 300 600

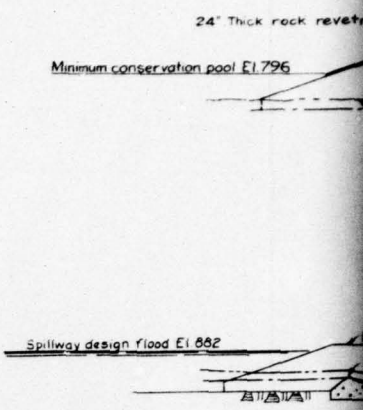
CONTOUR INTERVAL 20 FEET

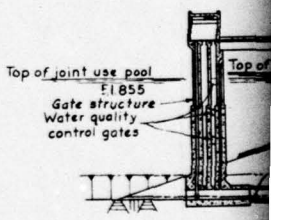


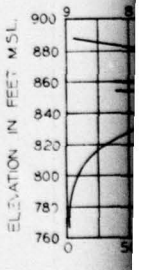
PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONTAL SCALE IN FEET

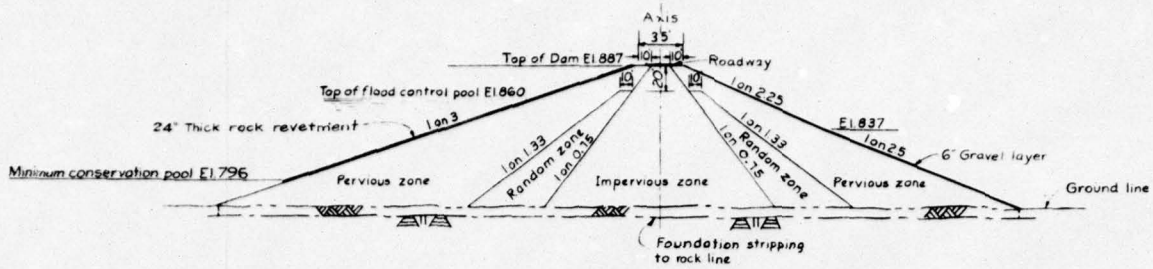
300 0 300 600







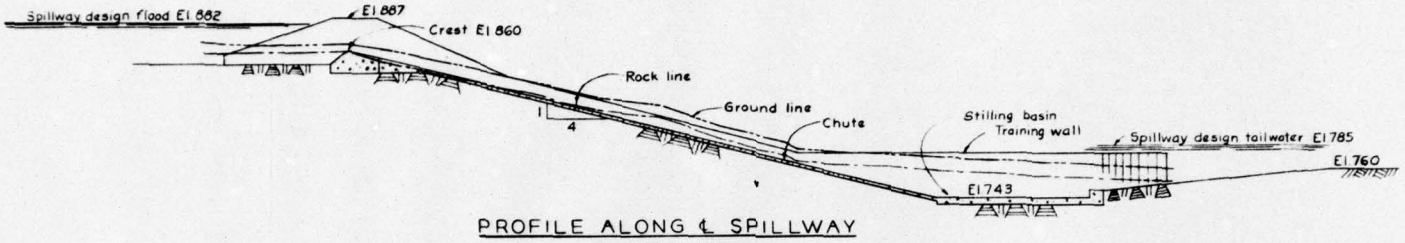
RESE



TYPICAL SECTION OF DAM

SCALE IN FEET

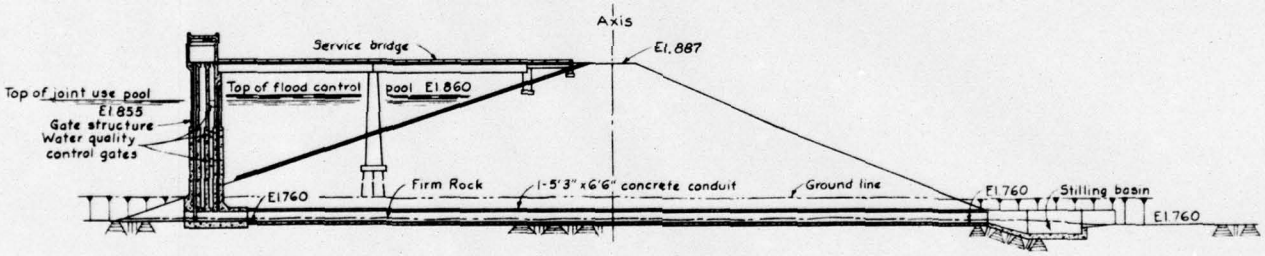
50 0 50 100



PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET

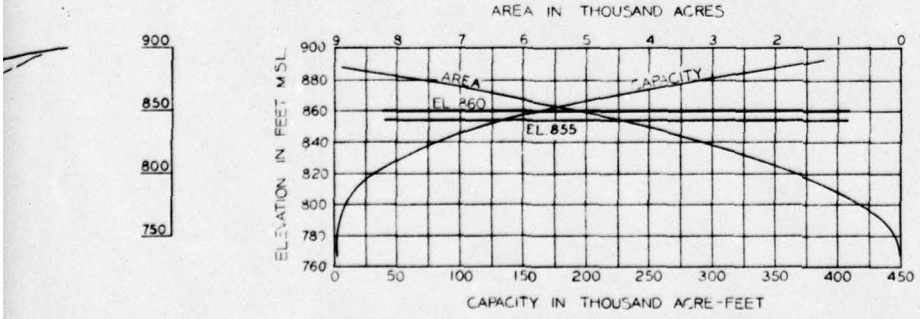
50 0 50 100



SECTION THRU OUTLET WORKS

SCALE IN FEET

50 0 50 100



RESERVOIR AREA AND CAPACITY CURVES

MERAMEC RIVER BASIN, MISSOURI

BIG RIVER

IRONDALE DAM

DESIGN DETAILS

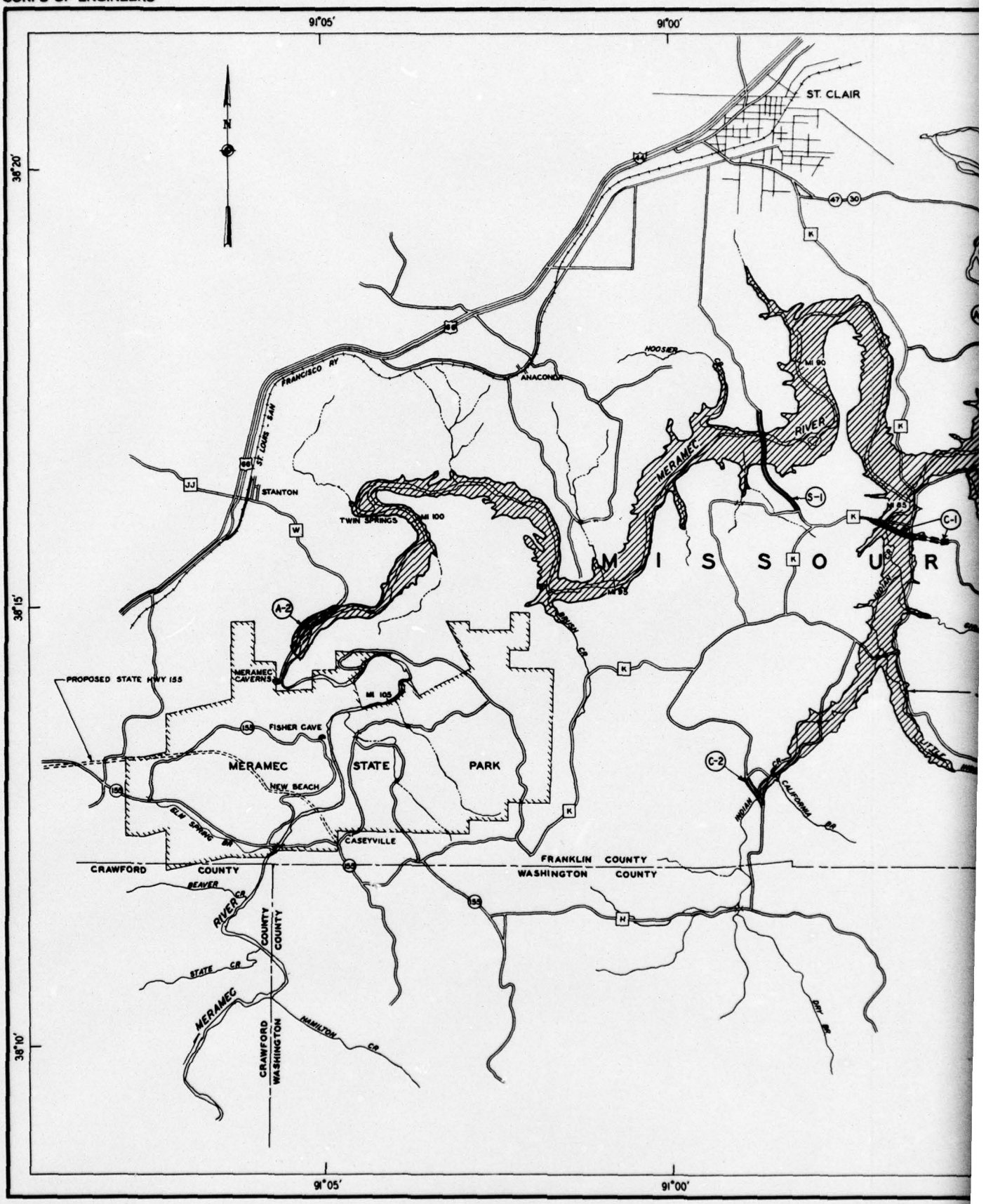
IN 1 SHEET SHEET NO. 1

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

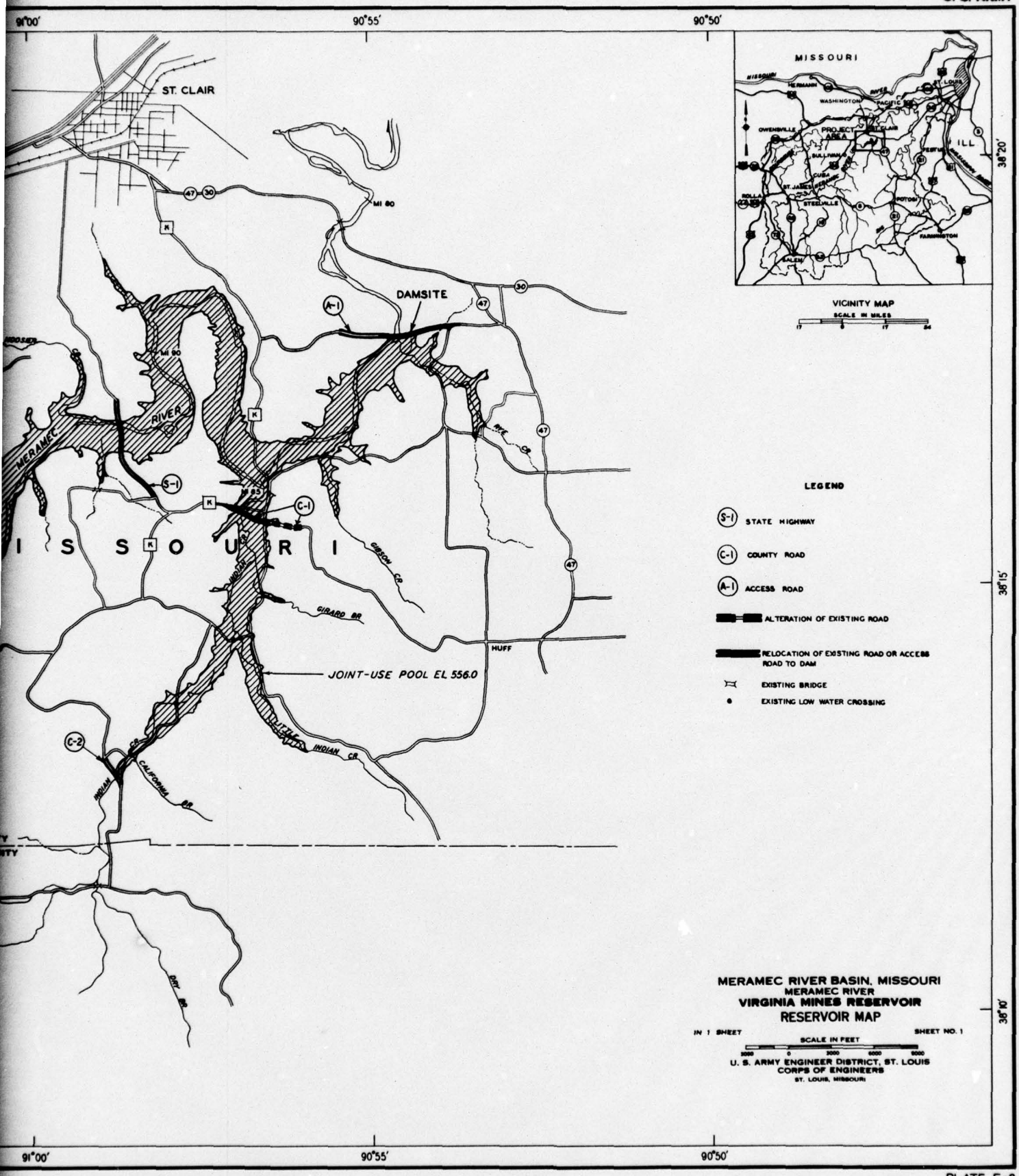
PLATE E-7

CORPS OF ENGINEERS



U. S. ARMY

2



MERAMEC RIVER BASIN, MISSOURI
MERAMEC RIVER
VIRGINIA MINES RESERVOIR
RESERVOIR MAP

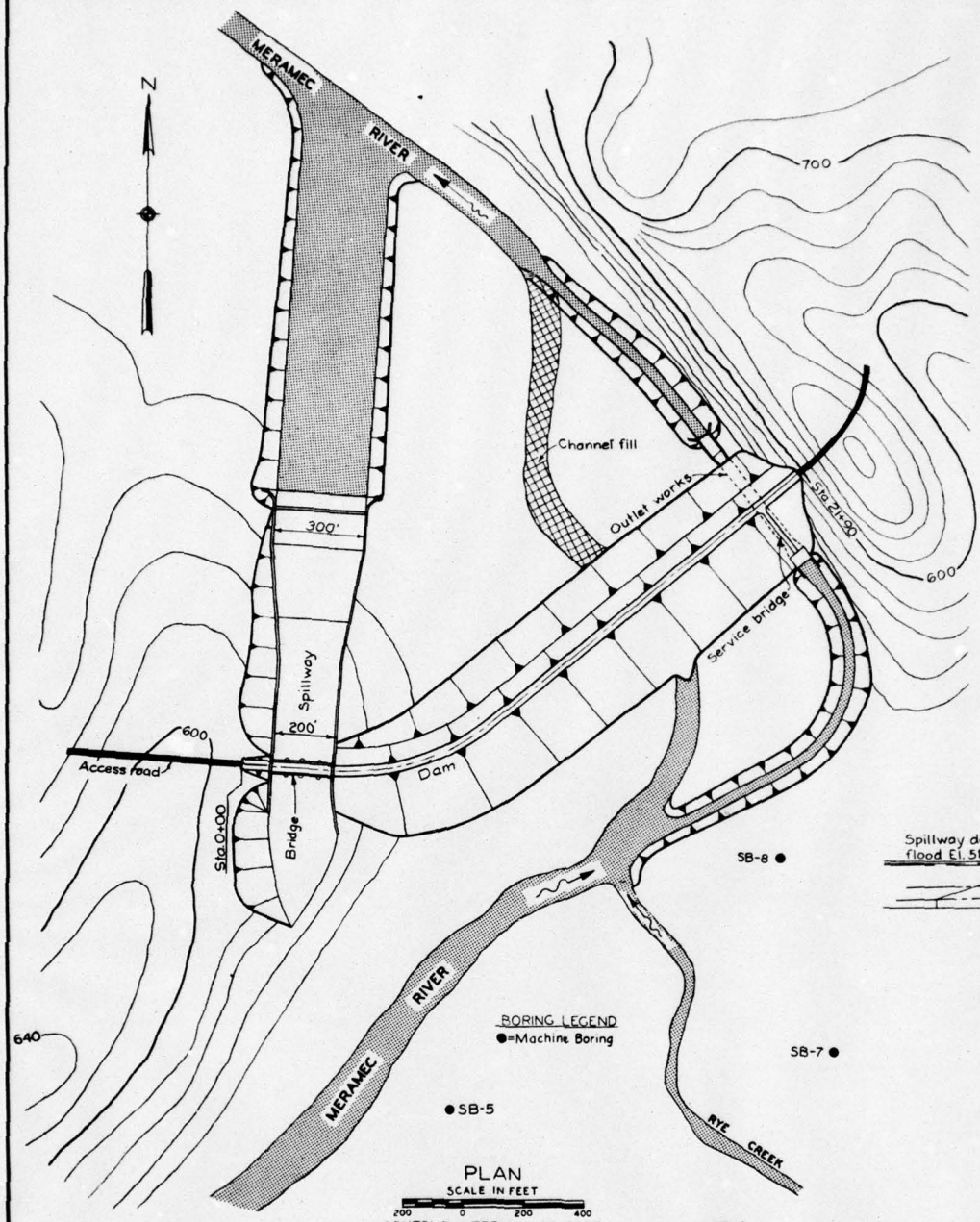
IN 1 SHEET SHEET NO. 1

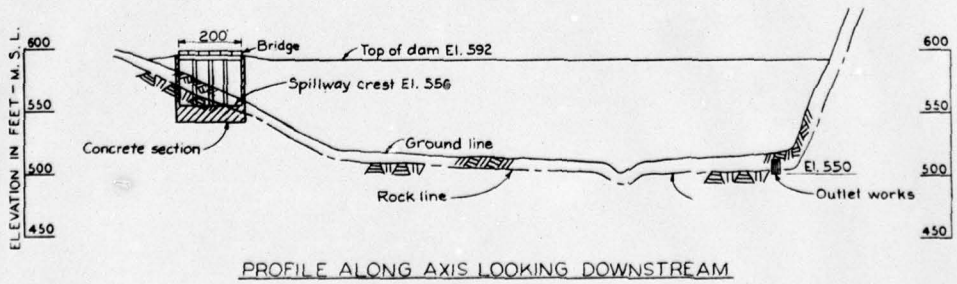
SCALE IN FEET

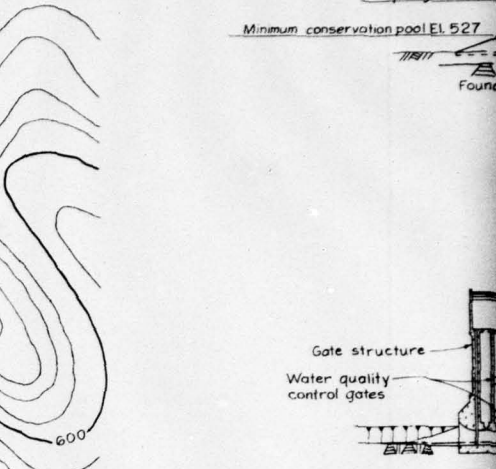
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

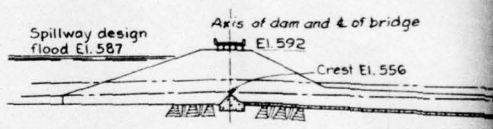
PLATE E-8

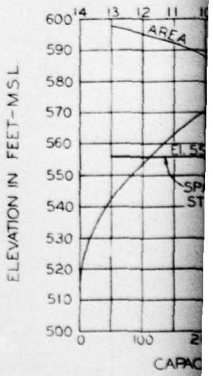
CORPS OF ENGINEERS



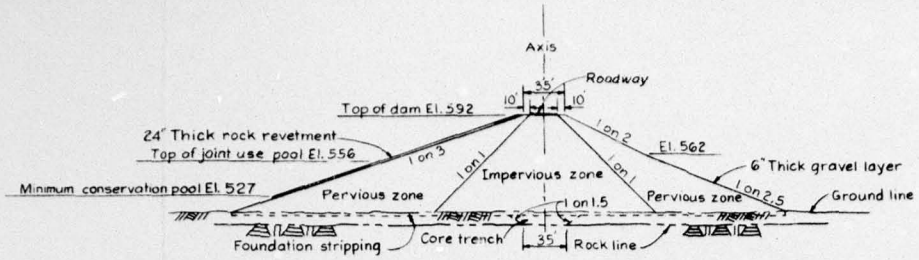








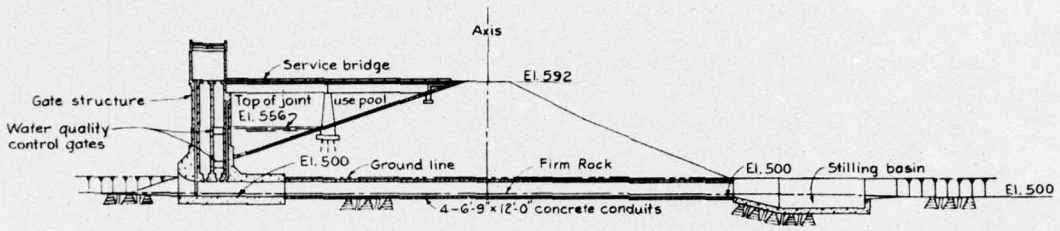
RESERVOIR A



TYPICAL SECTION OF DAM

SCALE IN FEET

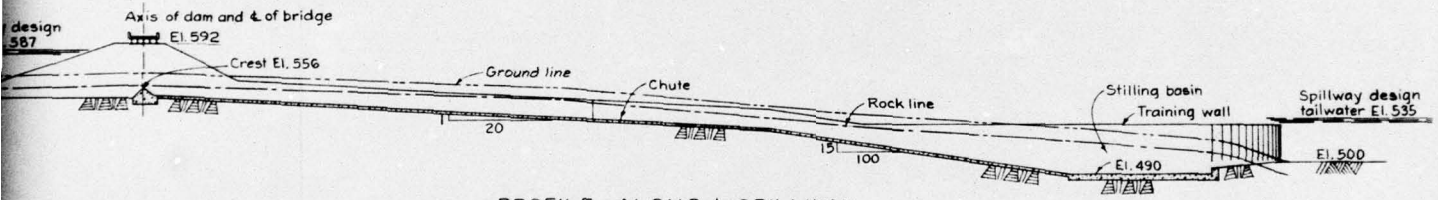
50 0 50 100



SECTION THRU OUTLET WORKS

SCALE IN FEET

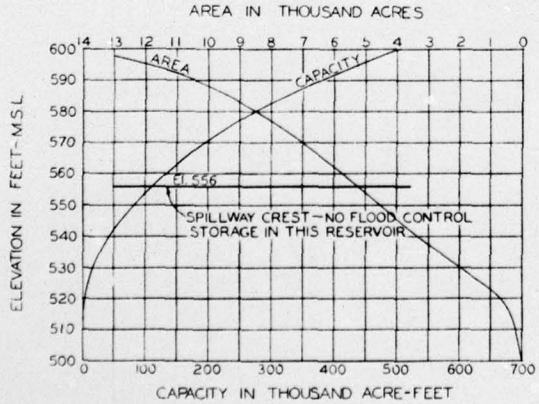
50 0 50 100



PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET

50 0 50 100



RESERVOIR AREA AND CAPACITY CURVES

MERAMEC RIVER BASIN, MISSOURI
MERAMEC RIVER
VIRGINIA MINES DAM
DESIGN DETAILS

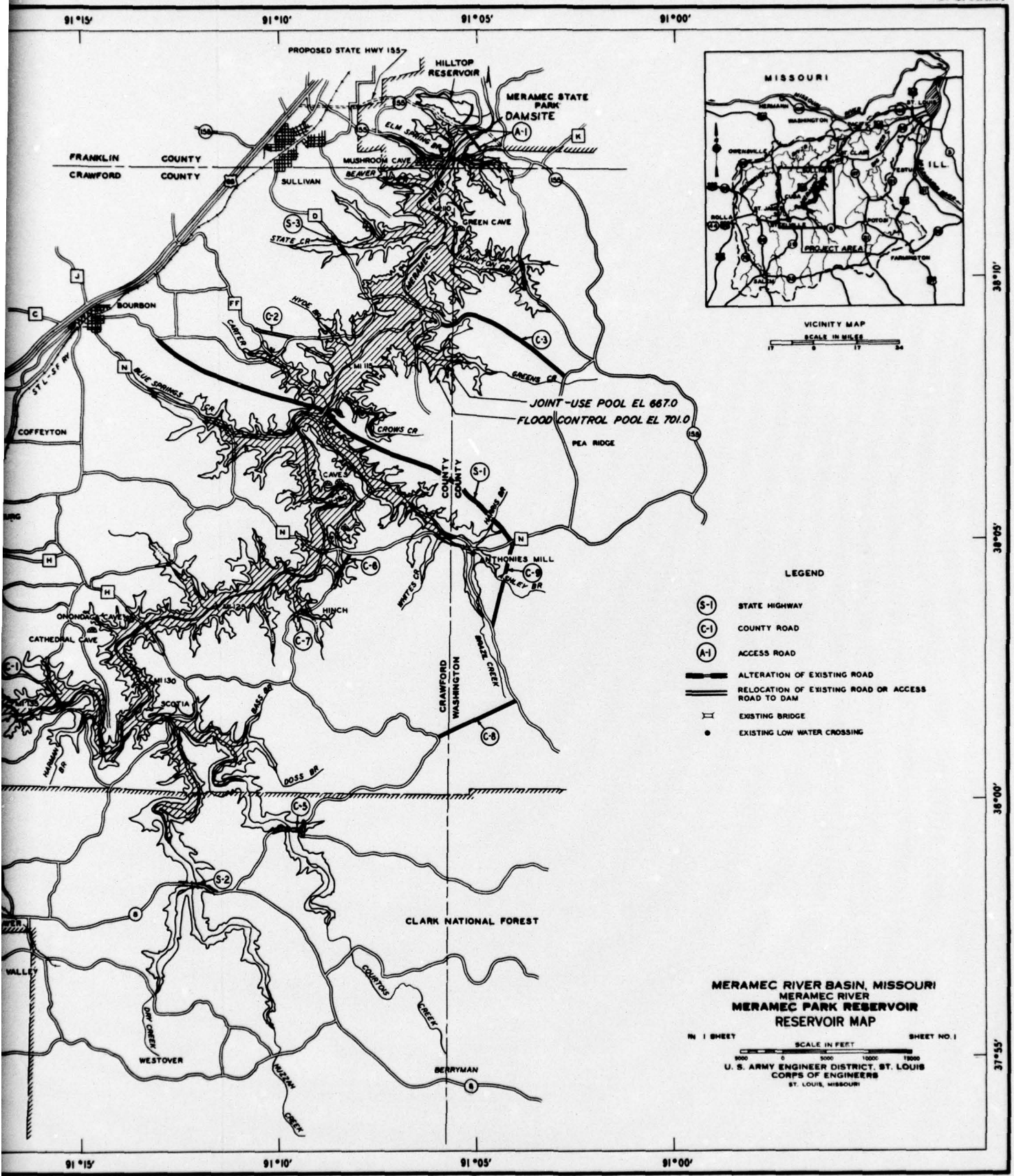
IN 1 SHEET SHEET NO. 1

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-9

CORPS OF ENGINEERS



MERAMEC RIVER BASIN, MISSOURI
MERAMEC RIVER
MERAMEC PARK RESERVOIR
RESERVOIR MAP

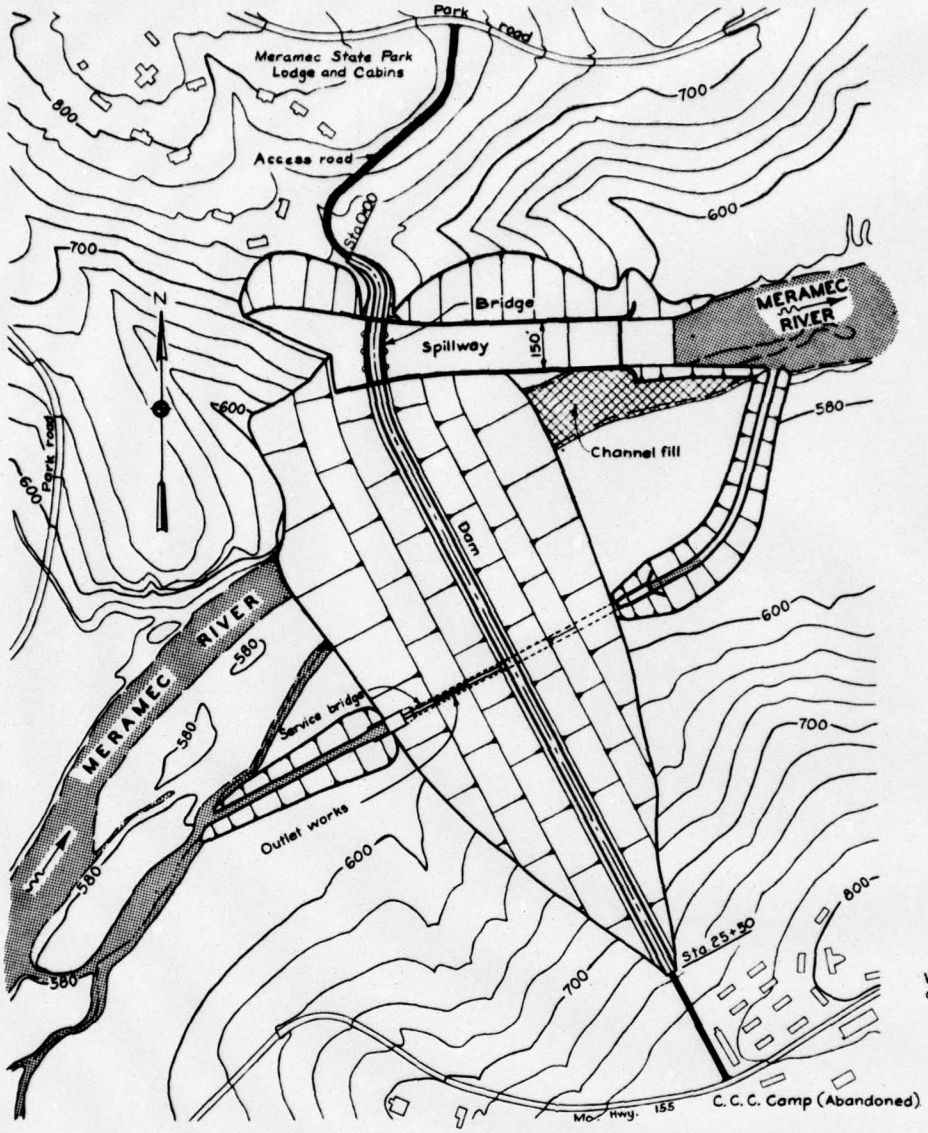
IN 1 SHEET SHEET NO. 1

SCALE IN FEET
9000 0 5000 10000 15000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-10

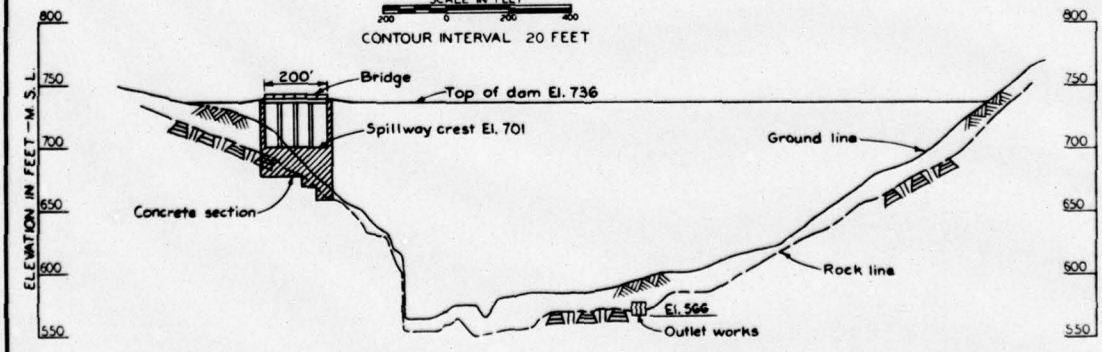
CORPS OF ENGINEERS



PLAN

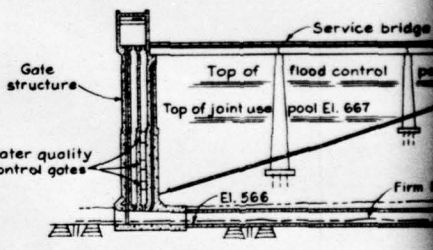
SCALE IN FEET
200 0 200 400

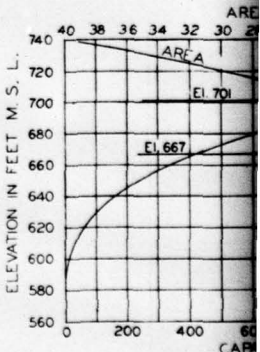
CONTOUR INTERVAL 20 FEET



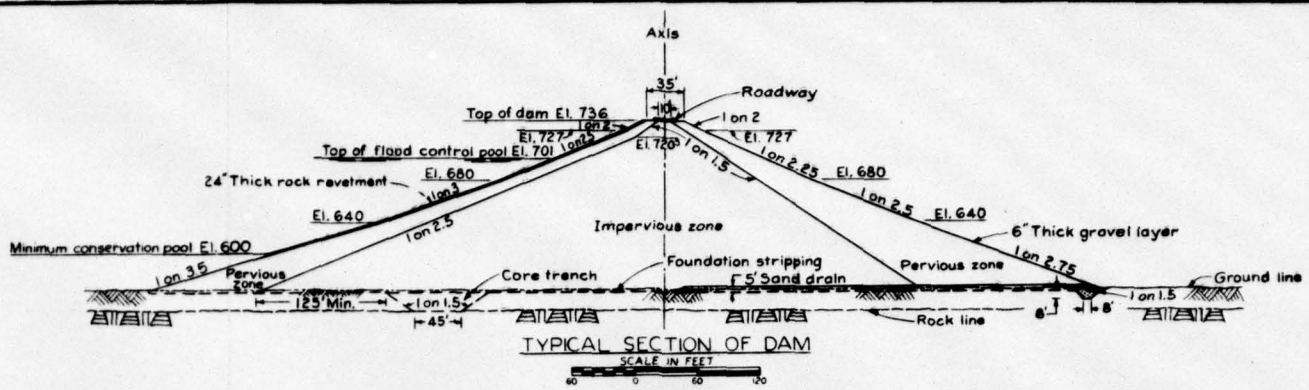
PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONTAL SCALE IN FEET
200 0 200 400





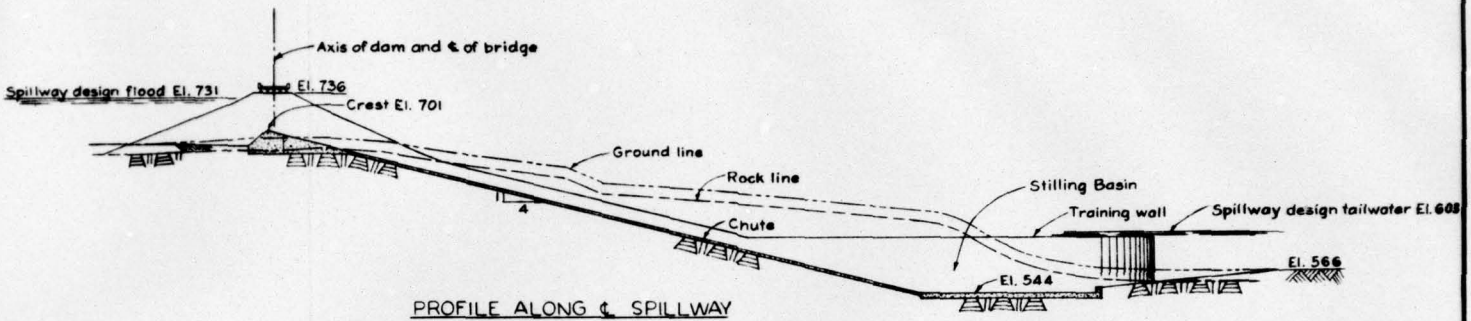
RESERVOI



TYPICAL SECTION OF DAM

SCALE IN FEET

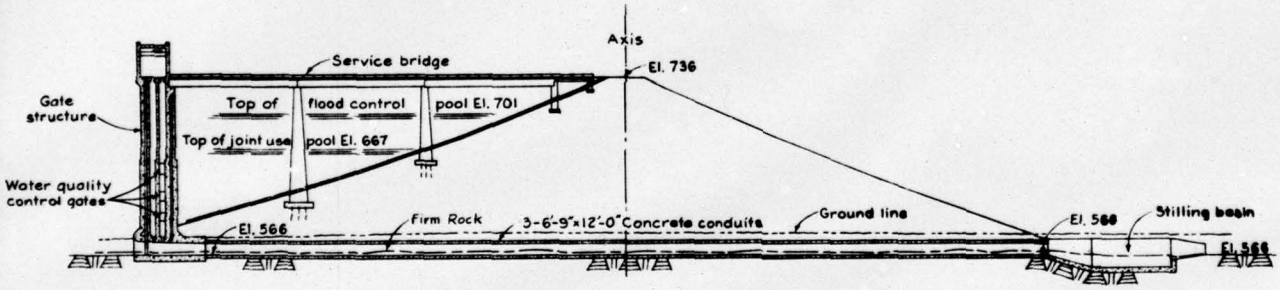
60 0 60 120



PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET

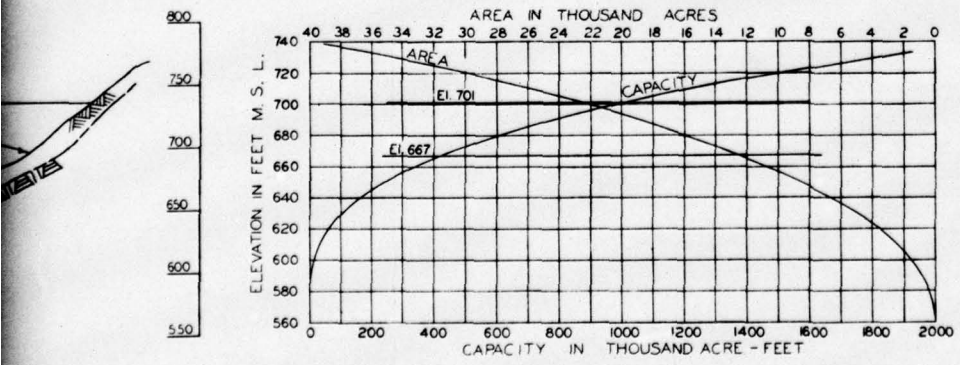
60 0 60 120



SECTION THRU OUTLET WORKS

SCALE IN FEET

60 0 60 120



RESERVOIR AREA AND CAPACITY CURVES

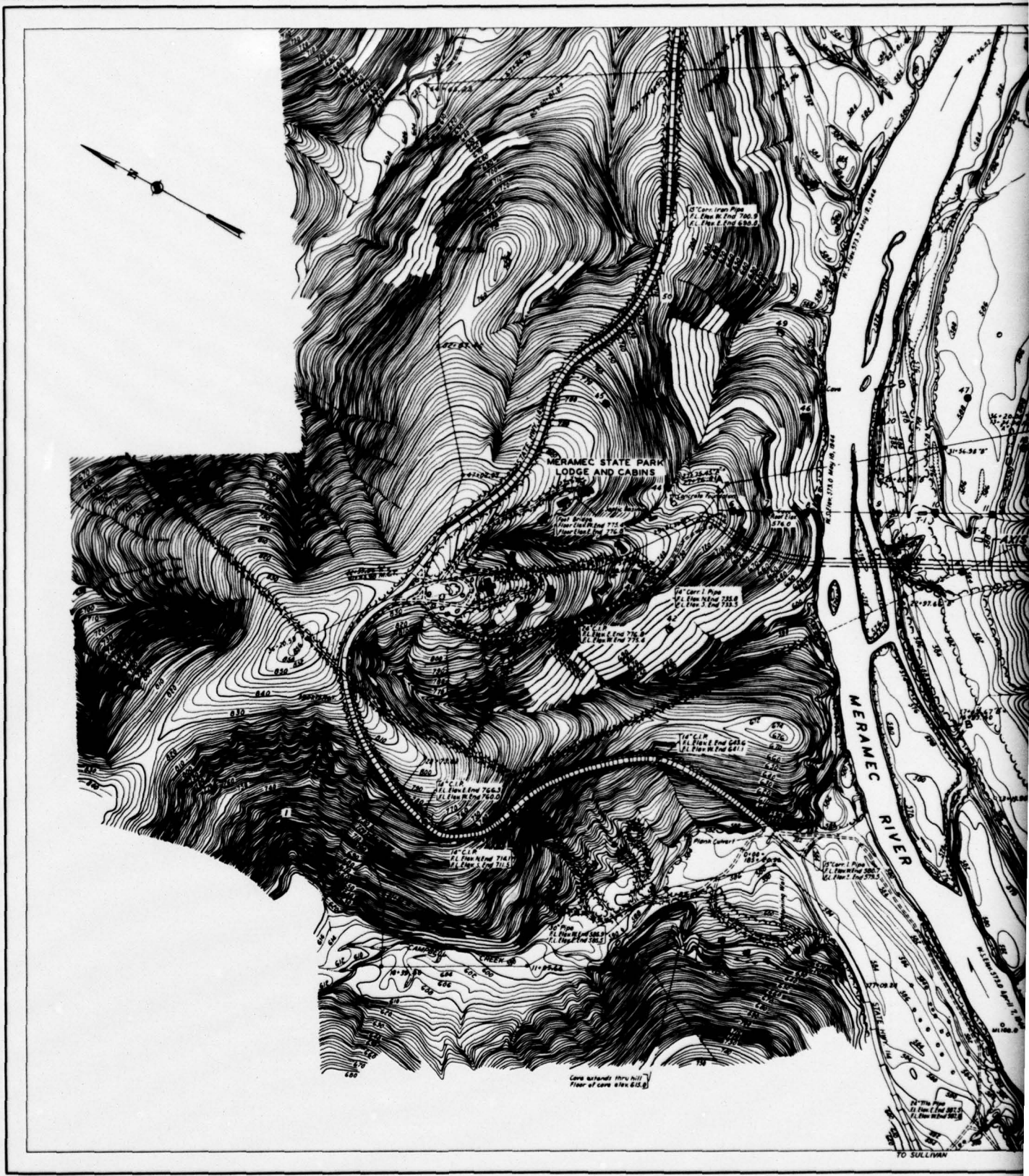
MERAMEC RIVER BASIN, MISSOURI
MERAMEC RIVER
MERAMEC PARK DAM
DESIGN DETAILS

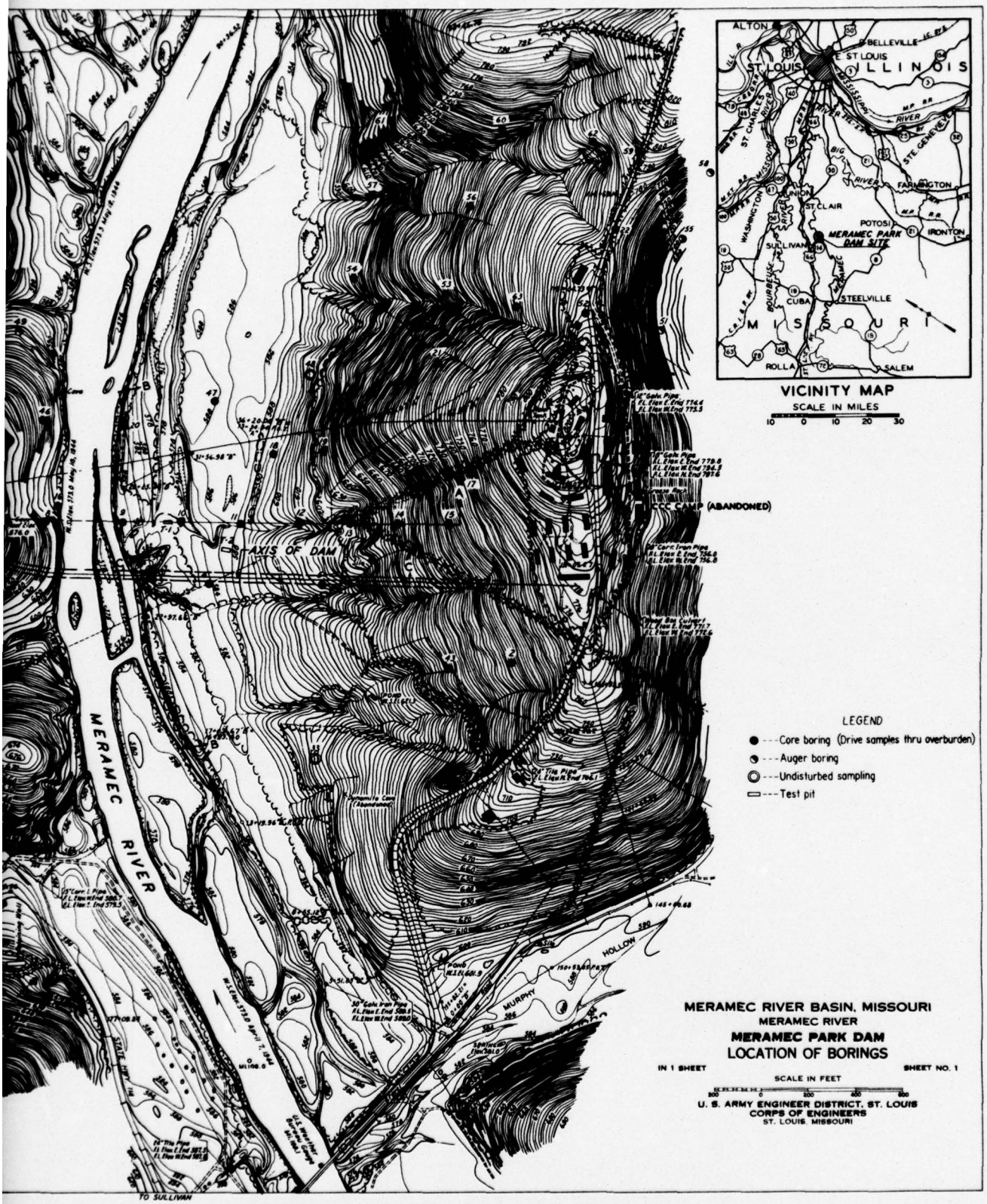
IN 1 SHEET — SHEET NO. 1

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS MISSOURI

PLATE E-11


MERAMEC STATE PARK
LODGE AND CABINS
MERAMEC RIVER
STATE HWY 14
TO SULLIVAN



VICINITY MAP

SCALE IN MILES

10 0 10 20 30

LEGEND

- ● --- Core boring (Drive samples thru overburden)
- ◔ --- Auger boring
- ◎ --- Undisturbed sampling
- ▭ --- Test pit

MERAMEC RIVER BASIN, MISSOURI

MERAMEC RIVER

MERAMEC PARK DAM

LOCATION OF BORINGS

IN 1 SHEET SHEET NO. 1

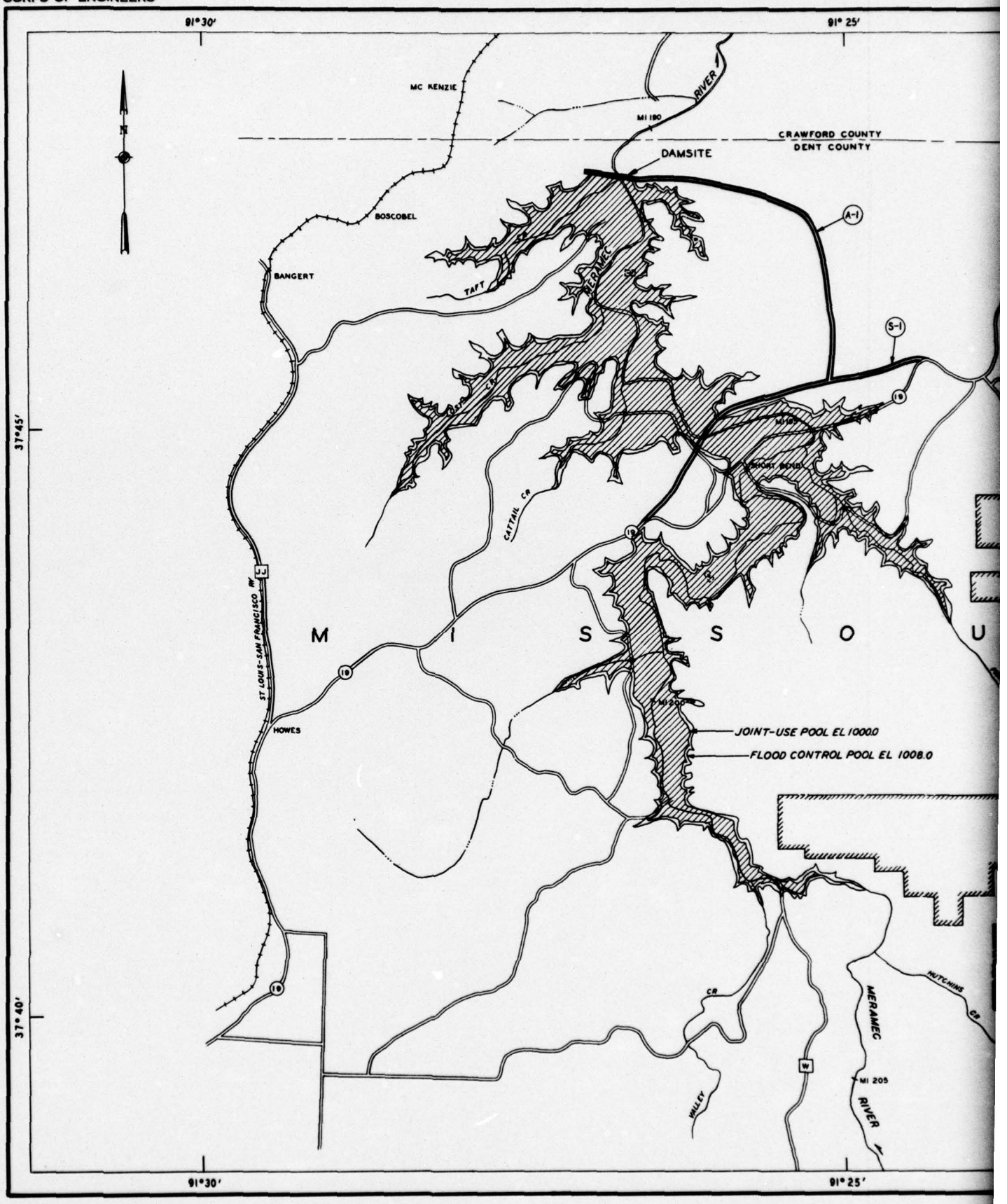
SCALE IN FEET

200 0 200 400 600

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-12

CORPS OF ENGINEERS



U. S. ARMY

91° 25'

91° 20'

CRAWFORD COUNTY
DENT COUNTY

A-1

SLIGO

S-1

MILES

SHORT BEND

S O U R I

FISHWATER CR

INDIAN TRAIL WILDLIFE AREA

JOINT-USE POOL EL 1000.0

FLOOD CONTROL POOL EL 1008.0

HUTCHINS CR

MERAMEC RIVER

MI 205

37° 45'

37° 40'

VICINITY MAP

SCALE IN MILES

17 0 17 34

LEGEND

S-1 STATE HIGHWAY

C-1 COUNTY ROAD

A-1 ACCESS ROAD

ALTERATION OF EXISTING ROAD

RELOCATION OF EXISTING ROAD OR ACCESS ROAD TO DAM

EXISTING BRIDGE

EXISTING LOW WATER CROSSING

MERAMEC RIVER BASIN, MISSOURI
MERAMEC RIVER
SALEM RESERVOIR
RESERVOIR MAP

IN 1 SHEET SHEET NO. 1

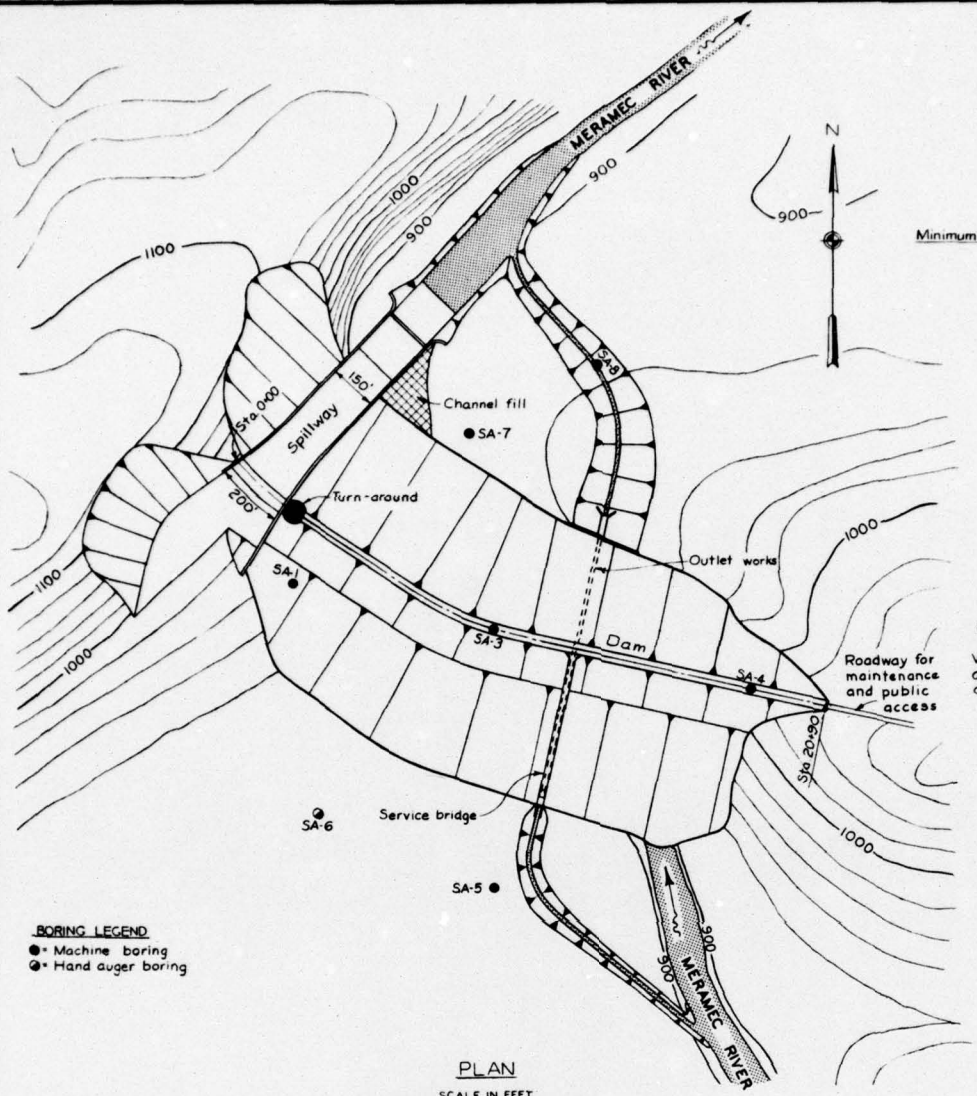
SCALE IN FEET

2000 0 2000 4000 6000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-13

CORPS OF ENGINEERS

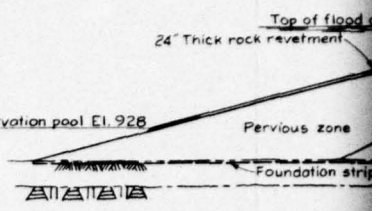


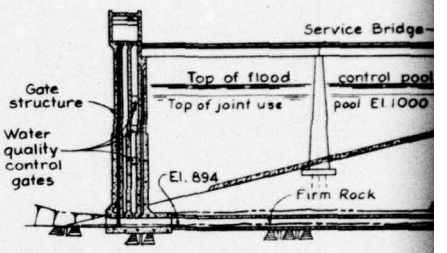
PLAN

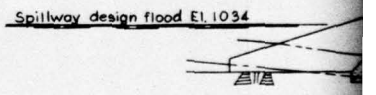
SCALE IN FEET

200 0 200 400

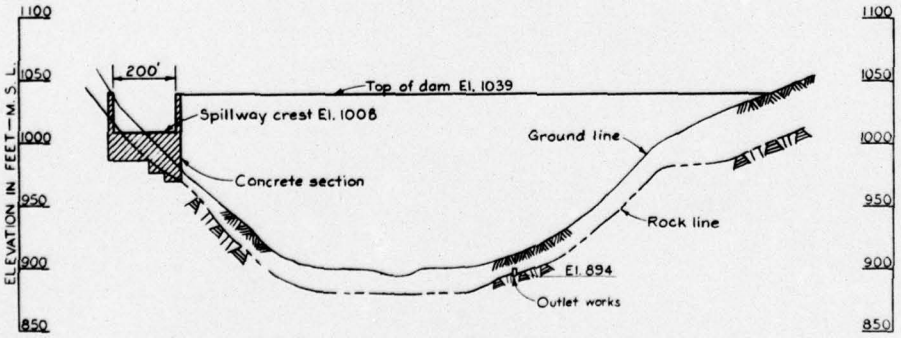
CONTOUR INTERVAL 20 FEET







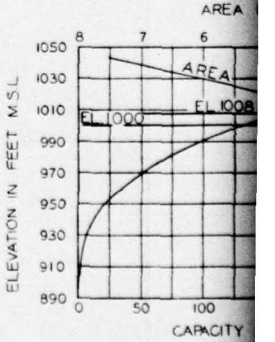
PROFI



PROFILE ALONG AXIS LOOKING DOWNSTREAM

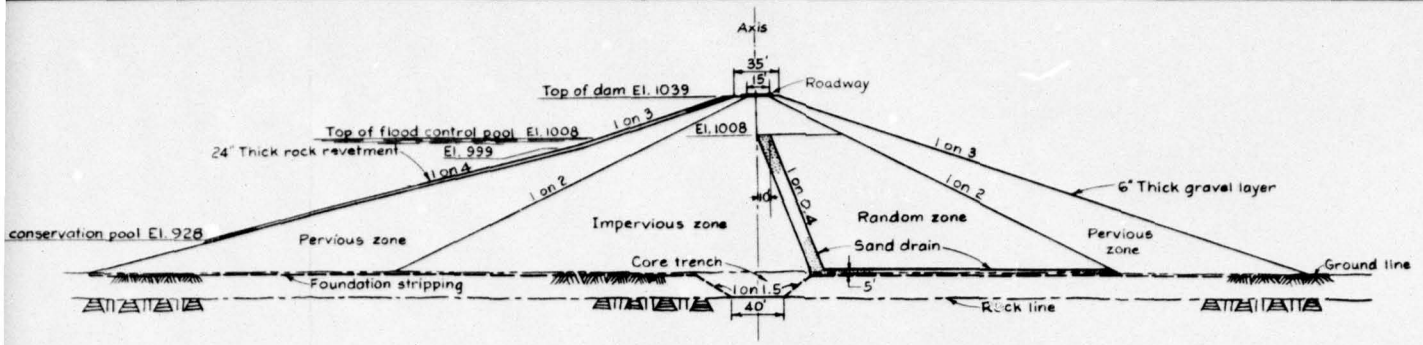
HORIZONTAL SCALE IN FEET

200 0 200 400



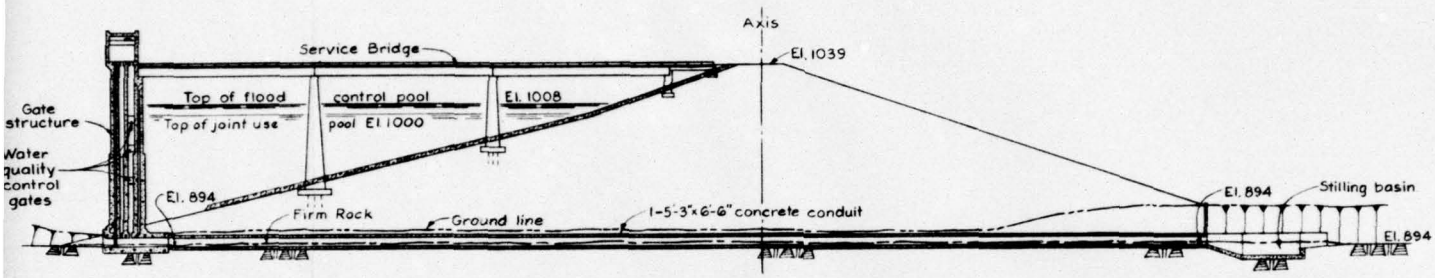
RESERVOIR AR

U. S. ARMY



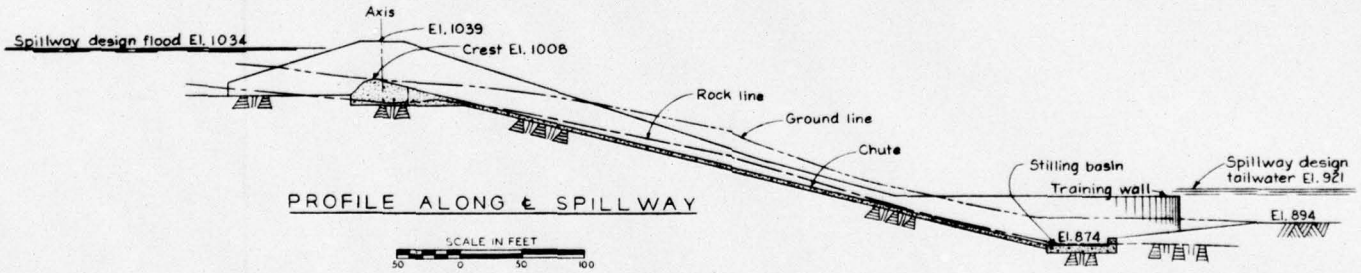
TYPICAL SECTION OF DAM

SCALE IN FEET
50 0 50 100



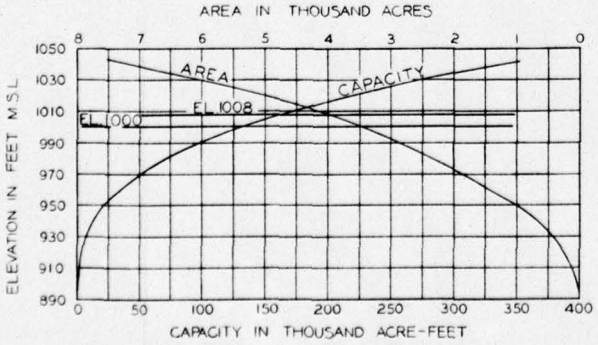
SECTION THRU OUTLET WORKS

SCALE IN FEET
50 0 50 100



PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET
50 0 50 100



RESERVOIR AREA AND CAPACITY CURVES

MERAMEC RIVER BASIN, MISSOURI
MERAMEC RIVER
SALEM DAM
DESIGN DETAILS

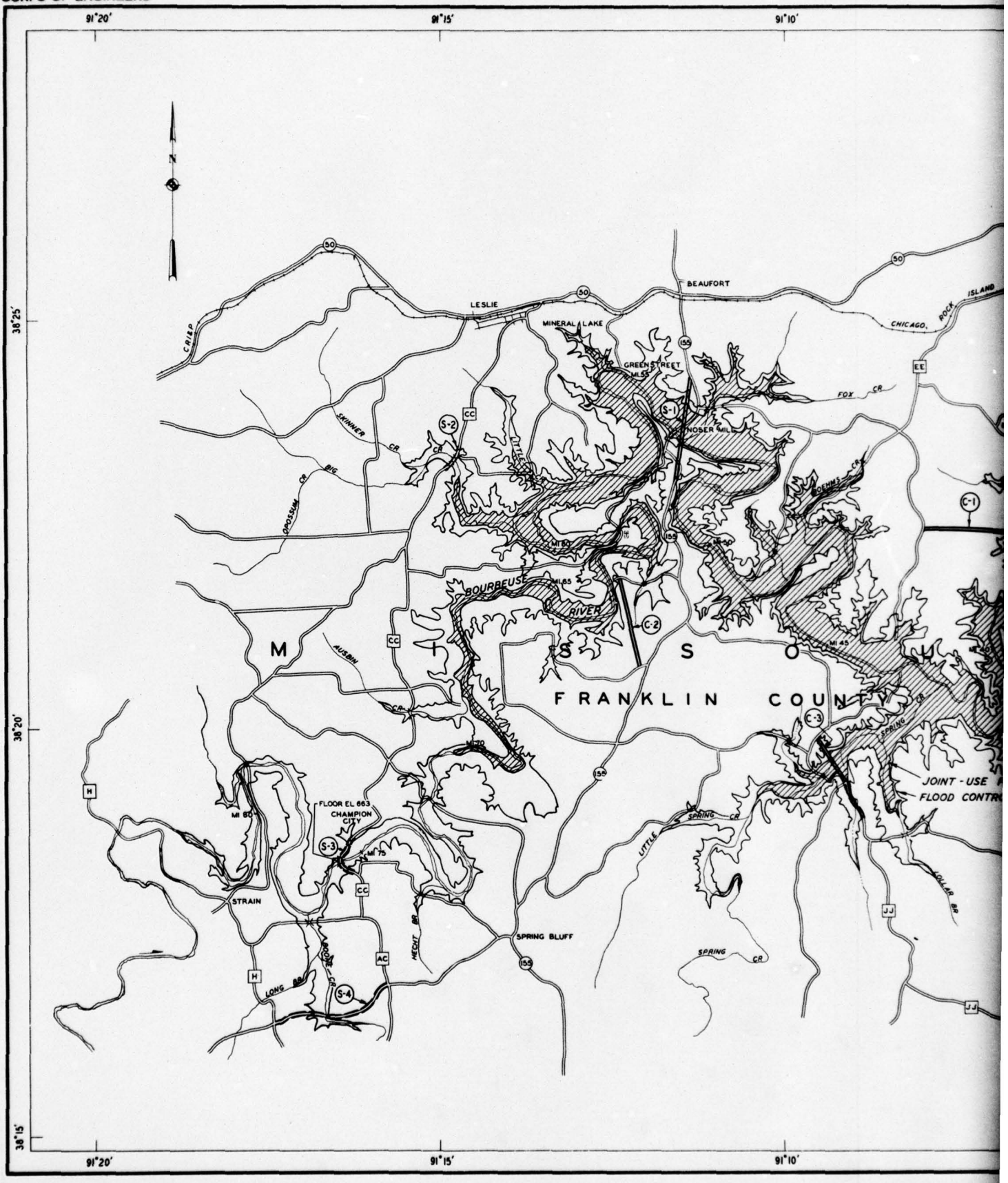
IN 1 SHEET SHEET NO. 1

SCALE AS SHOWN

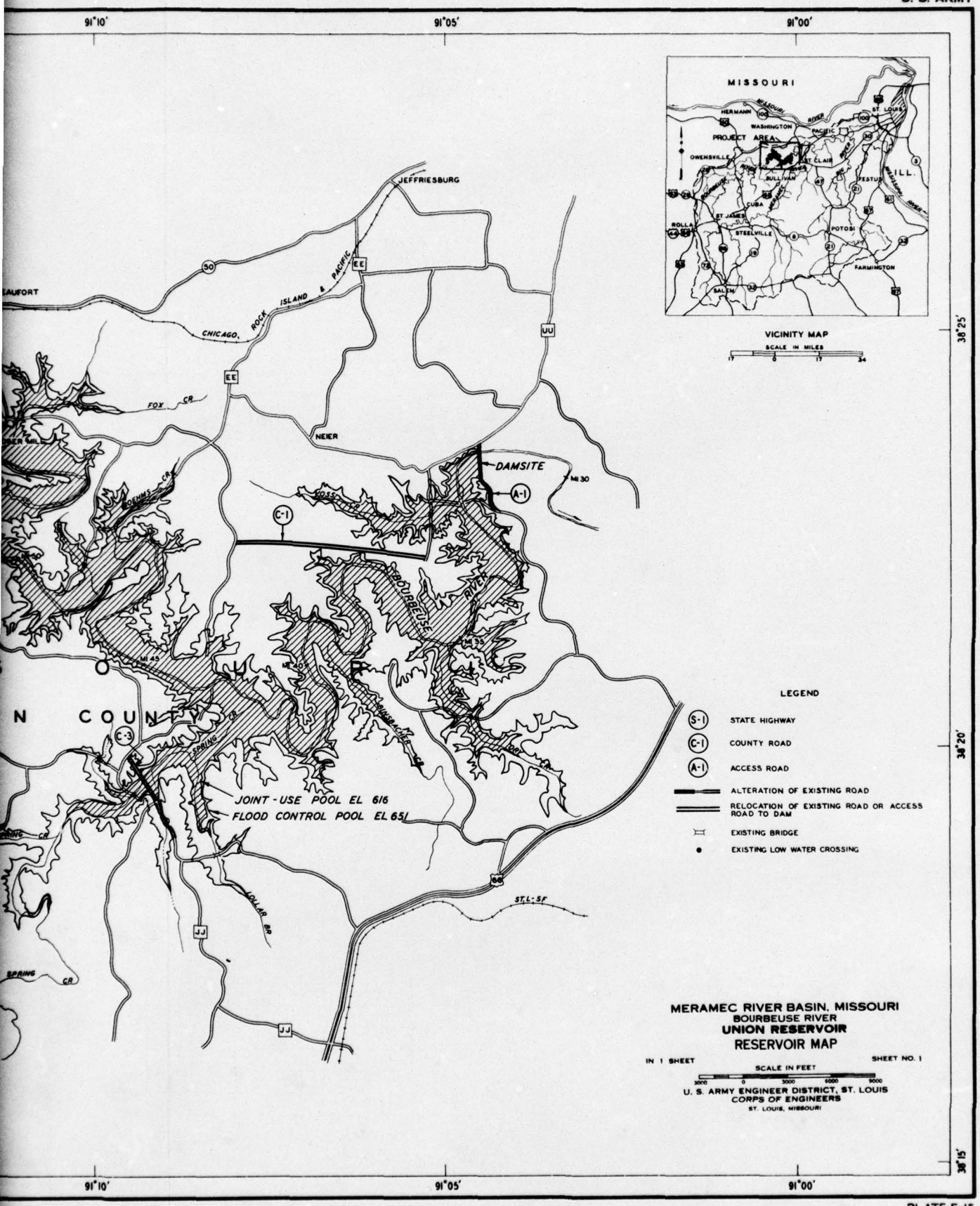
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-14

CORPS OF ENGINEERS



U. S. ARMY



MERAMEC RIVER BASIN, MISSOURI
BOURBEUSE RIVER
UNION RESERVOIR
RESERVOIR MAP

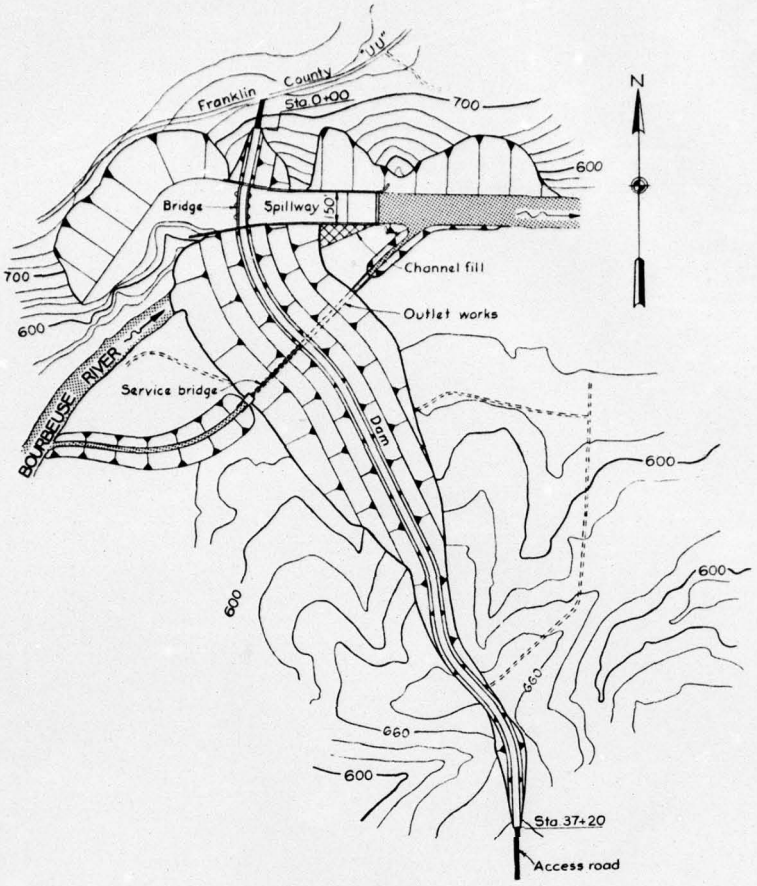
IN 1 SHEET SHEET NO. 1

SCALE IN FEET
3000 0 3000 6000 9000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-15

CORPS OF ENGINEERS

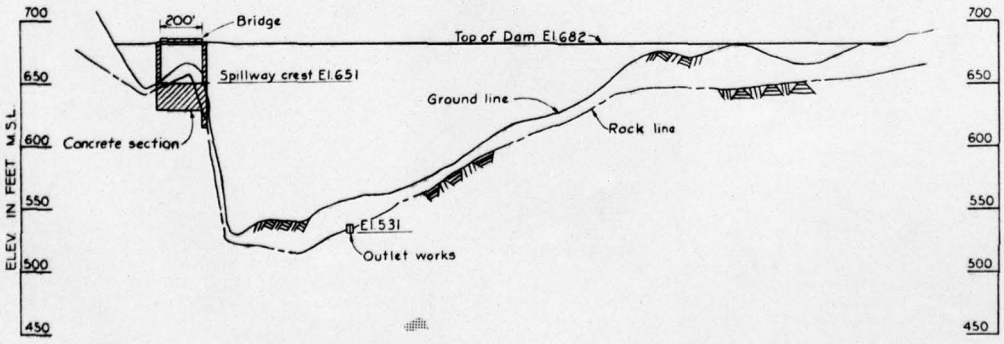


PLAN

SCALE IN FEET

300 0 300 600

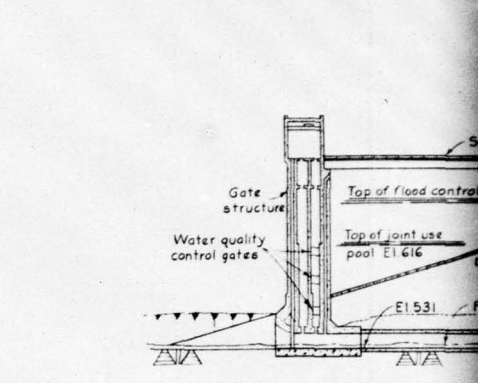
CONTOUR INTERVAL 20 FEET

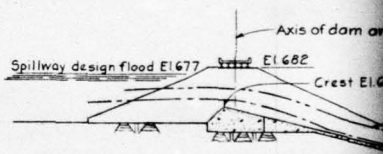


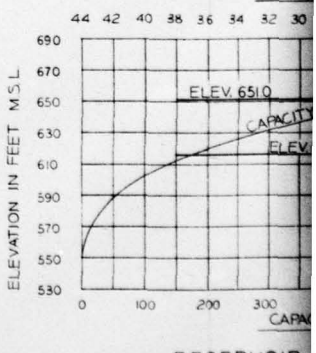
PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONTAL SCALE IN FEET

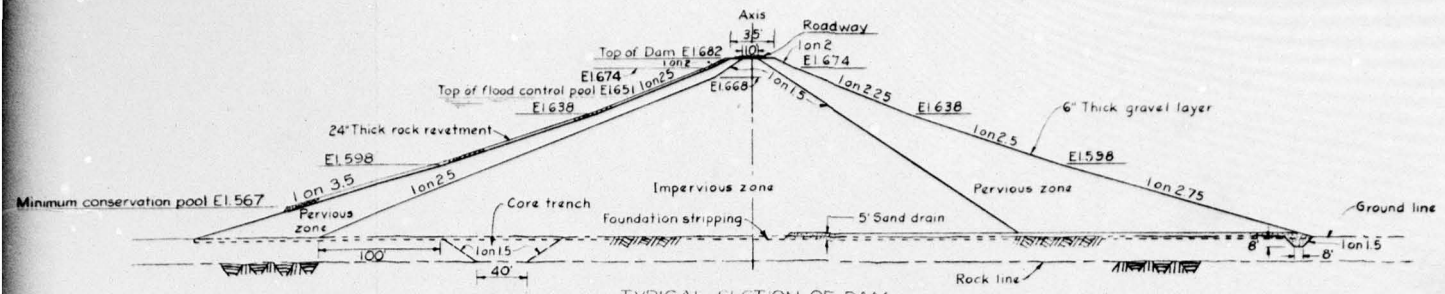
300 0 300 600







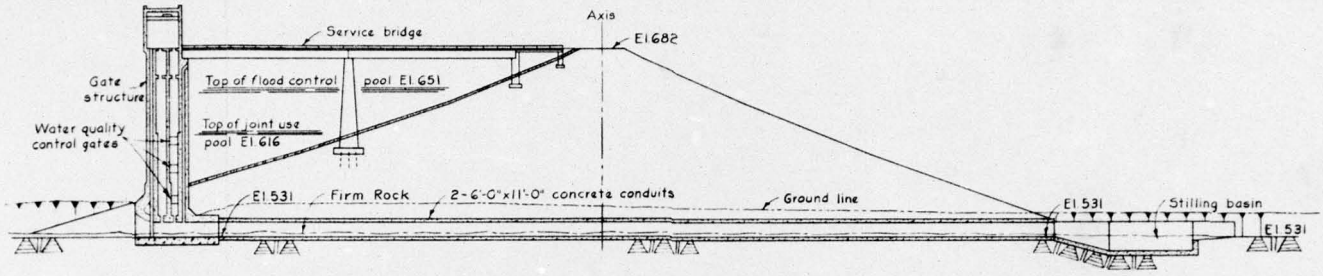
RESERVOIR



TYPICAL SECTION OF DAM

SCALE IN FEET

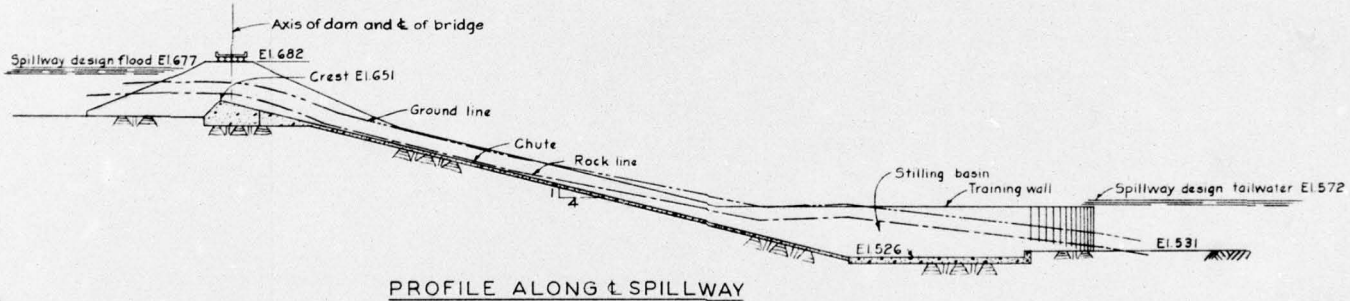
50 0 50 100



SECTION THRU OUTLET WORKS

SCALE IN FEET

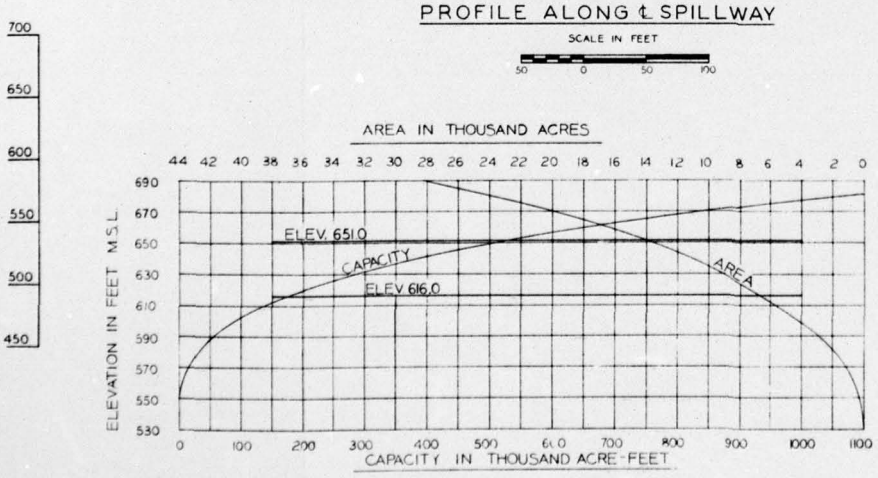
50 0 50 100



PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET

50 0 50 100



RESERVOIR AREA AND CAPACITY CURVES

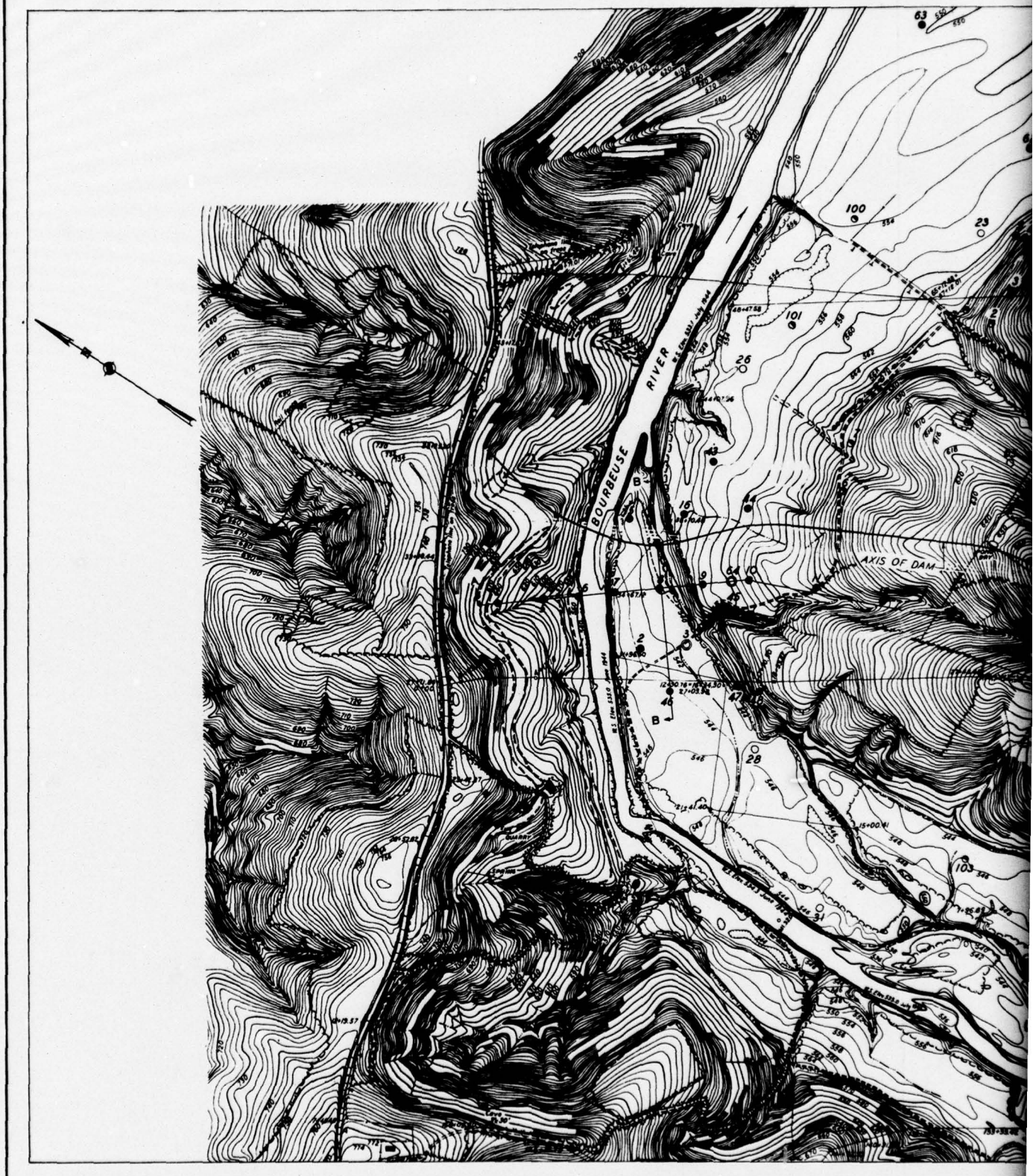
MERAMEC RIVER BASIN, MISSOURI
BOURBEUSE RIVER
UNION DAM
DESIGN DETAILS

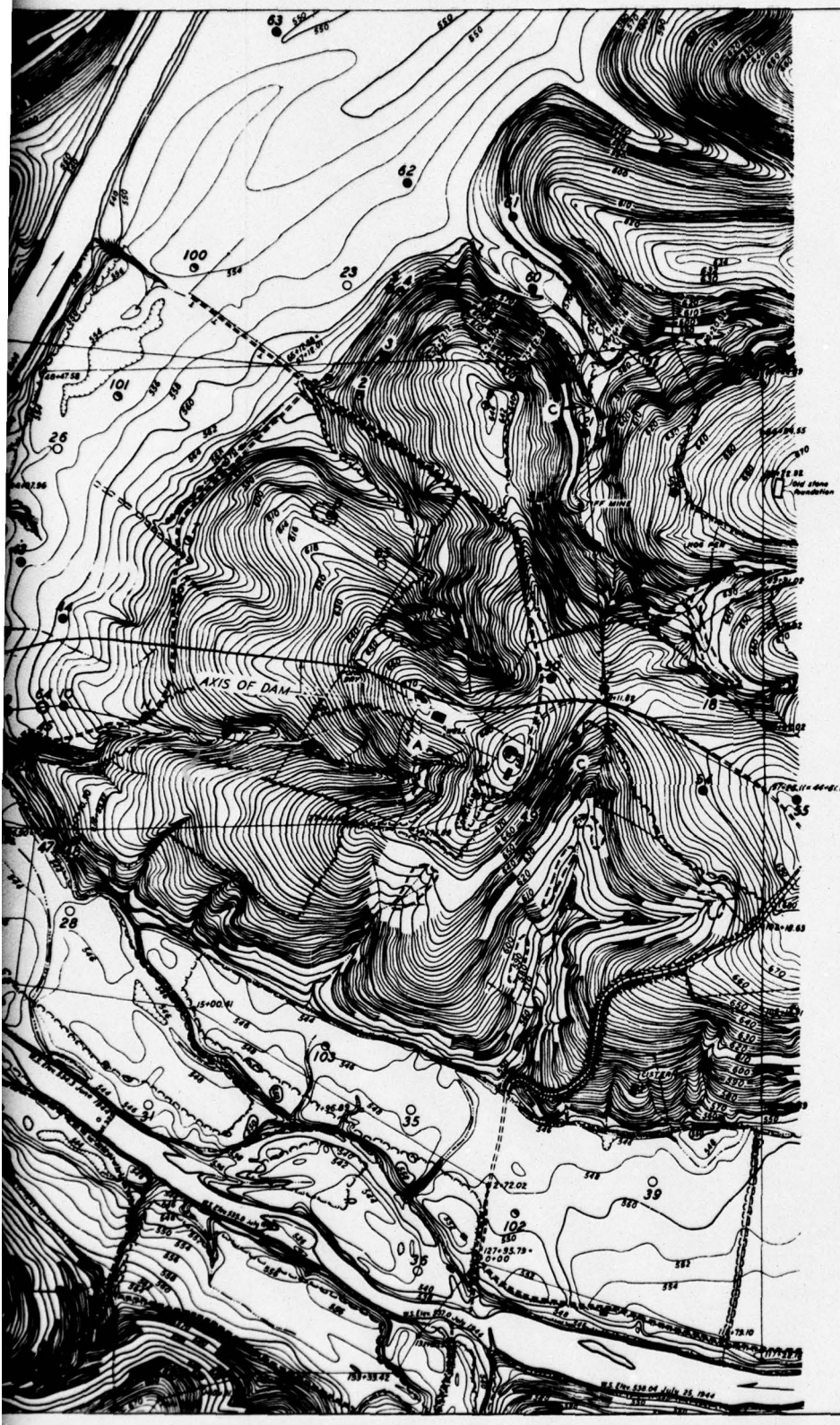
IN 1 SHEET SHEET NO. 1

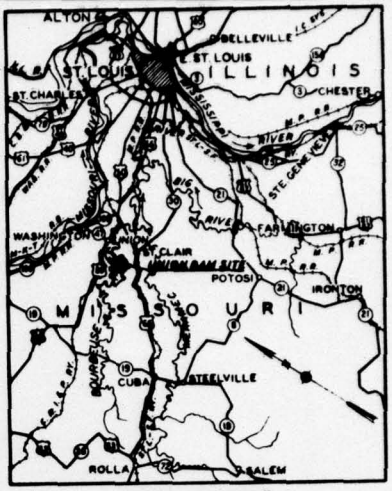
SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS MISSOURI

PLATE E-18


BOURBEUSE
RIVER
AXIS OF DAM





VICINITY MAP

SCALE IN MILES

10 0 10 20 30

LEGEND

- ● ---------- Core Boring (Drive Samples thru Overburden)
- ○ ---------- Drive Boring
- ◔ ---------- Auger Boring
- ◎ ---------- Undisturbed Sampling
- ⊏⊐ ---------- Rock outcrop

MERAMEC RIVER BASIN, MISSOURI
BOURBEUSE RIVER
UNION DAM
LOCATION OF BORINGS

IN 1 SHEET

SHEET NO. 1

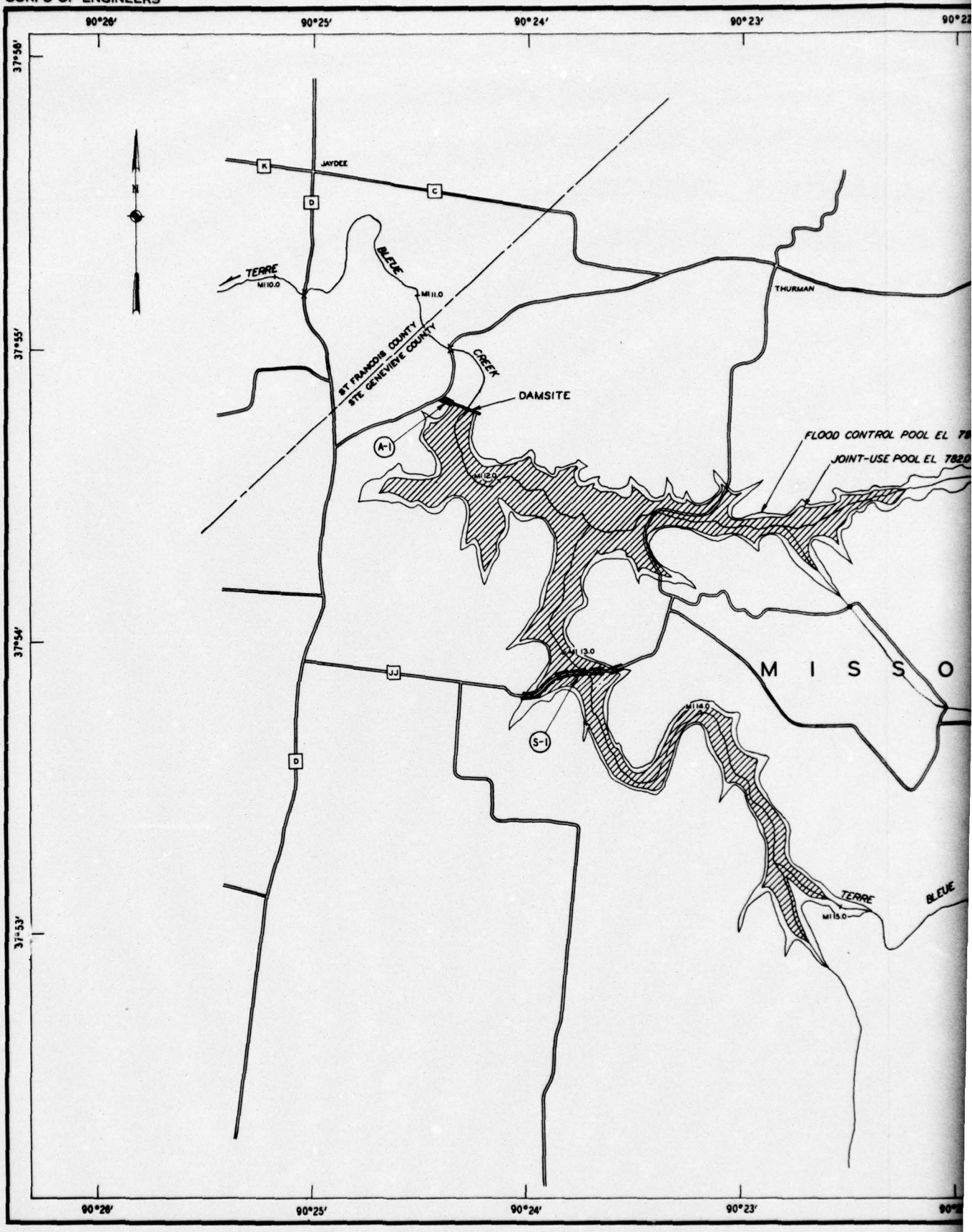
SCALE IN FEET

200 0 200 400 600

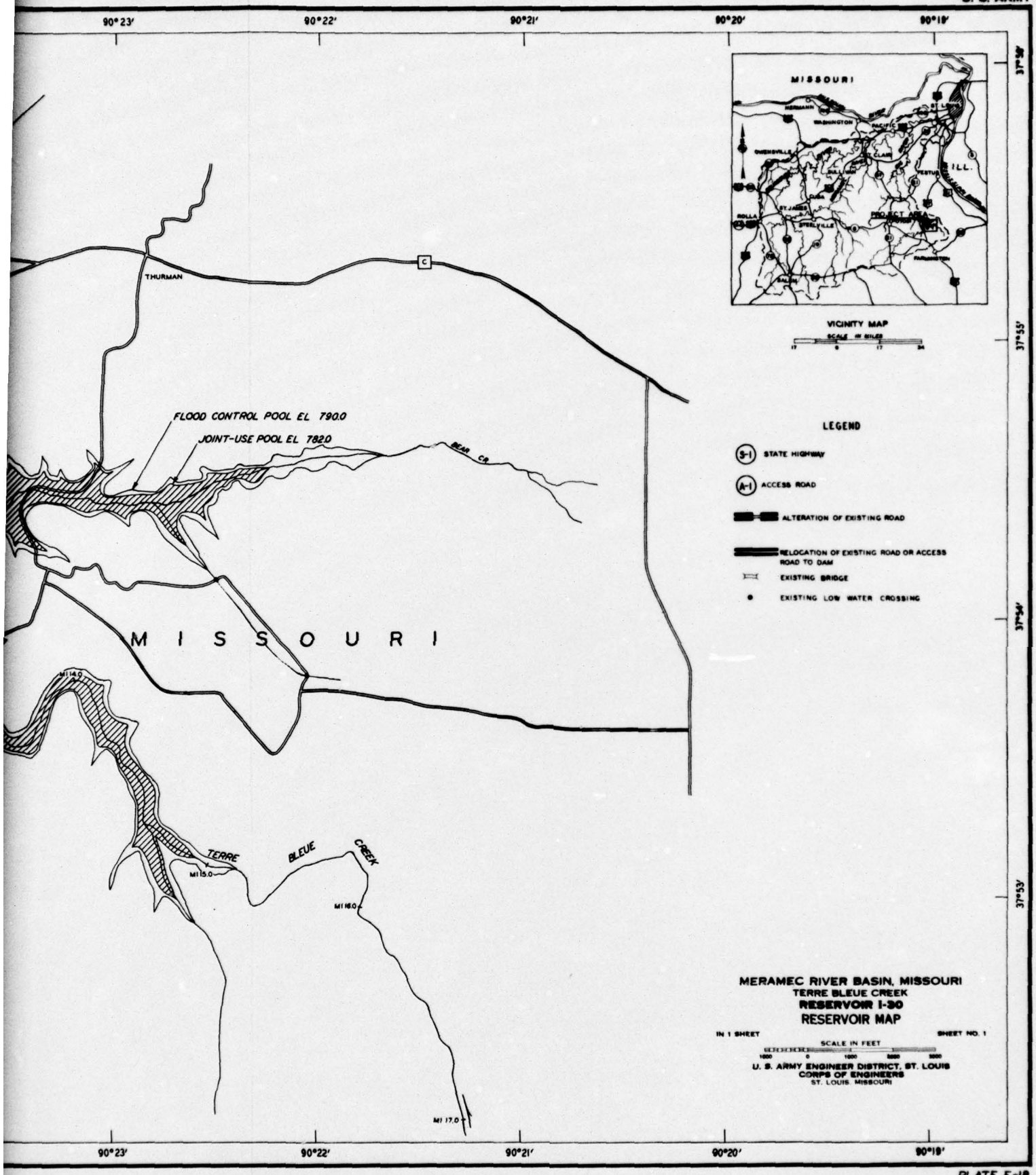
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-17

CORPS OF ENGINEERS



U. S. ARMY



MERAMEC RIVER BASIN, MISSOURI
TERRE BLEUE CREEK
RESERVOIR I-30
RESERVOIR MAP

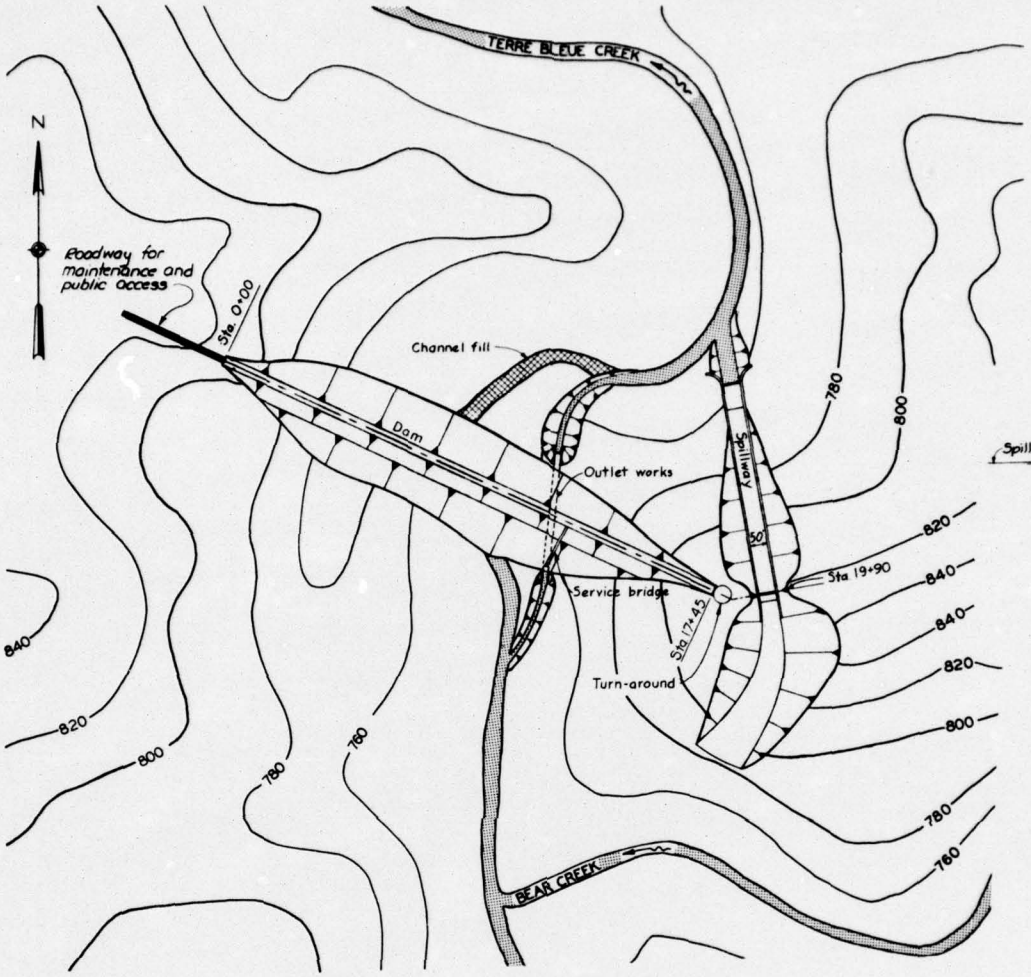
IN 1 SHEET SHEET NO. 1

SCALE IN FEET
1000 0 1000 2000 3000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-18

CORPS OF ENGINEERS

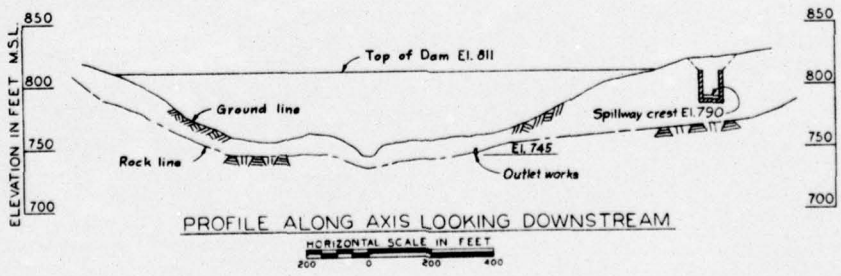


PLAN

SCALE IN FEET

200 0 200 400

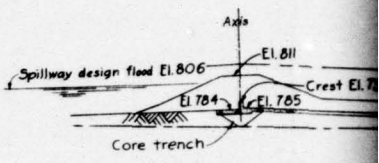
CONTOUR INTERVAL 20 FEET

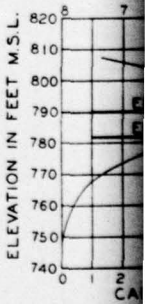


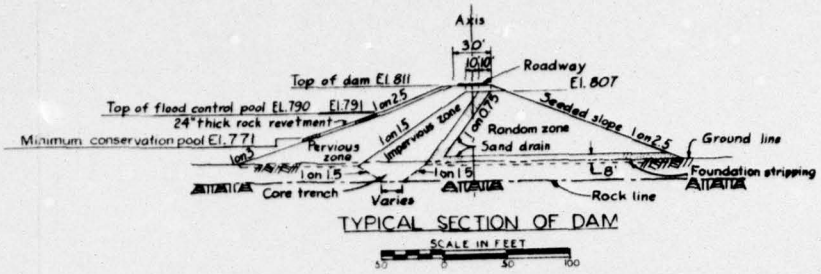
PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONTAL SCALE IN FEET

200 0 200 400



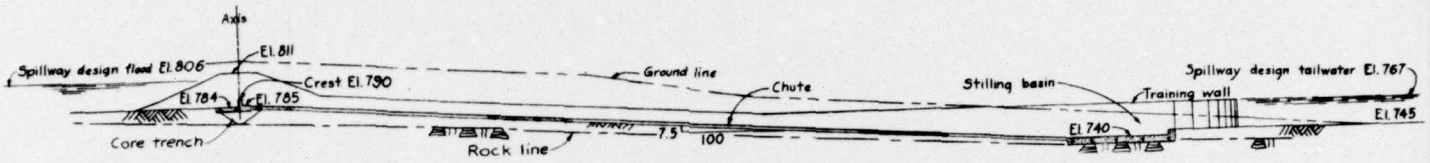




TYPICAL SECTION OF DAM

SCALE IN FEET

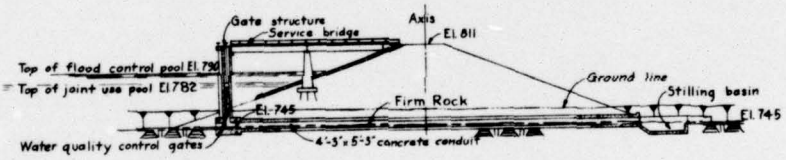
50 0 50 100



PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET

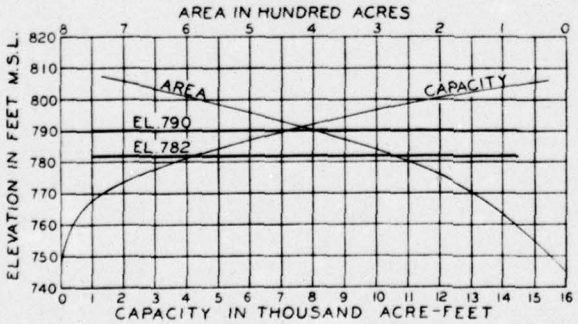
50 0 50 100



SECTION THRU OUTLET WORKS

SCALE IN FEET

50 0 50 100



RESERVOIR AREA AND CAPACITY CURVES

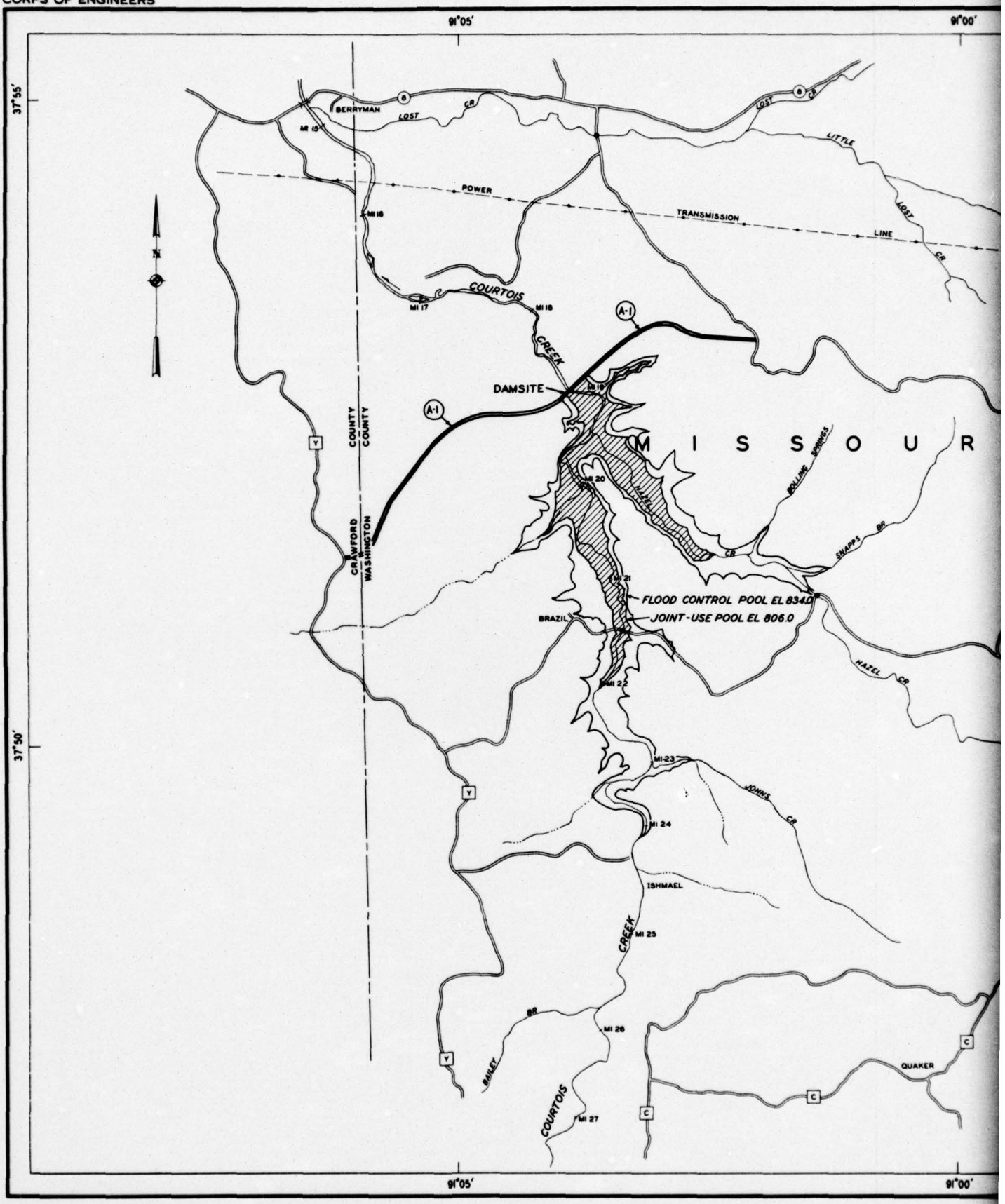
MERAMEC RIVER BASIN, MISSOURI
TERRE BLEUE CREEK
DAM I-30
DESIGN DETAILS

IN 1 SHEET SCALE AS SHOWN SHEET NO. 1

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS MISSOURI

PLATE E-19

CORPS OF ENGINEERS



2

91°00'

90°55'

37°55'

37°50'

LOST CR.

LITTLE LOST CR.

TRANSMISSION LINE

ROLLING SPRINGS

SNAPPS BR

CONTROL POOL EL 834.0

T-USE POOL EL 806.0

PALMER

HAZEL CR

JOHNS CR

DELBRIDGE

QUAKER

C

VICINITY MAP

SCALE IN MILES

17 0 17 34

LEGEND

A-1 ACCESS ROAD

RELOCATION OF EXISTING ROAD OR ACCESS ROAD TO DAM

EXISTING BRIDGE

EXISTING LOW WATER CROSSING

MERAMEC RIVER BASIN, MISSOURI

COURTOIS CREEK

RESERVOIR I-15A

RESERVOIR MAP

IN 1 SHEET SHEET NO. 1

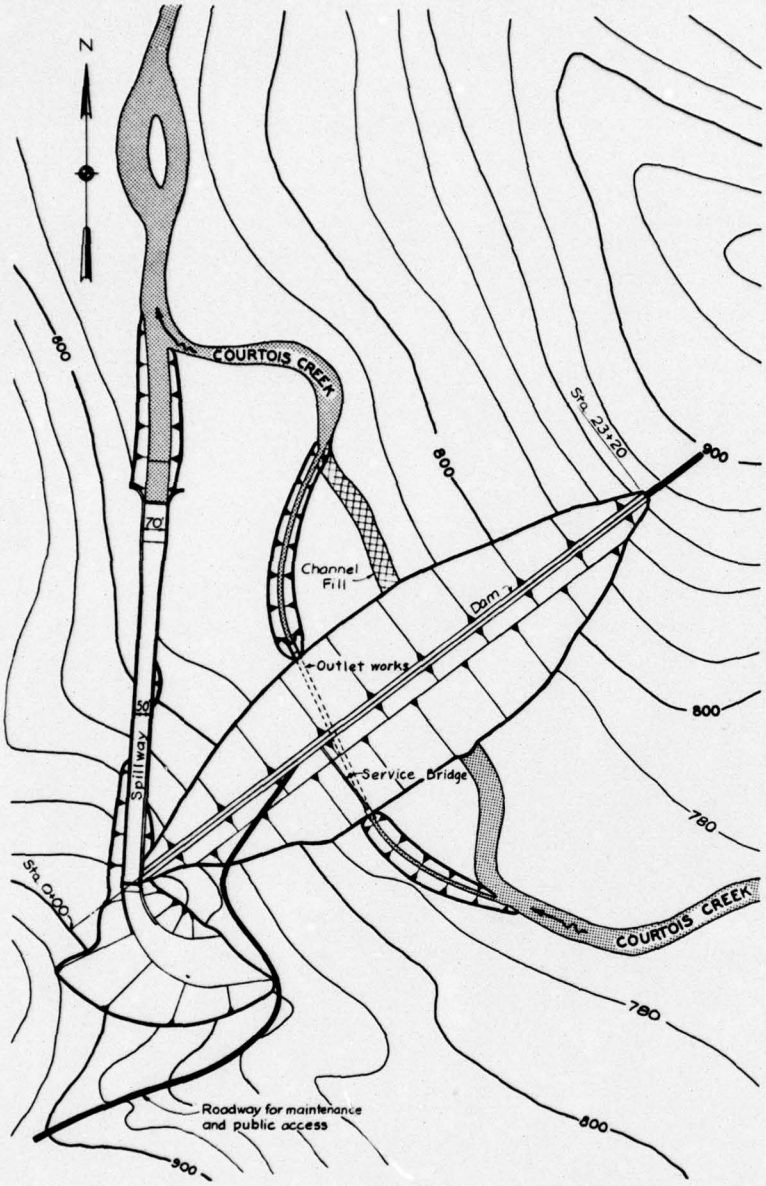
SCALE IN FEET

2000 0 2000 4000 6000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-20

CORPS OF ENGINEERS

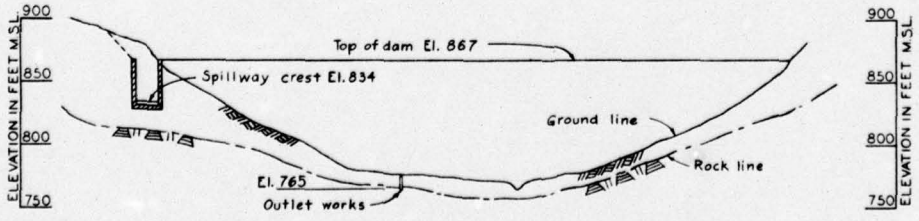


PLAN

SCALE IN FEET

200 0 200 400

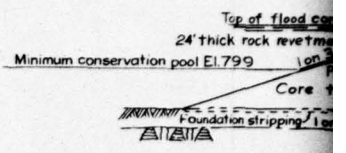
CONTOUR INTERVAL 20 FEET

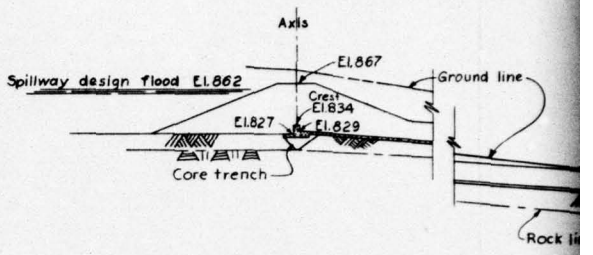


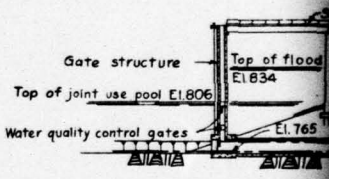
PROFILE ALONG AXIS LOOKING DOWNSTREAM

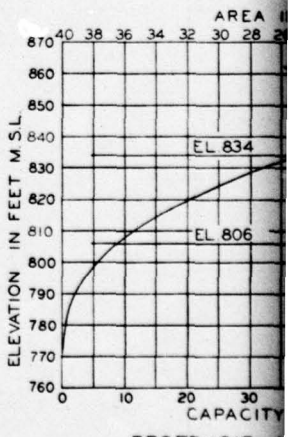
HORIZONTAL SCALE IN FEET

200 0 200 400

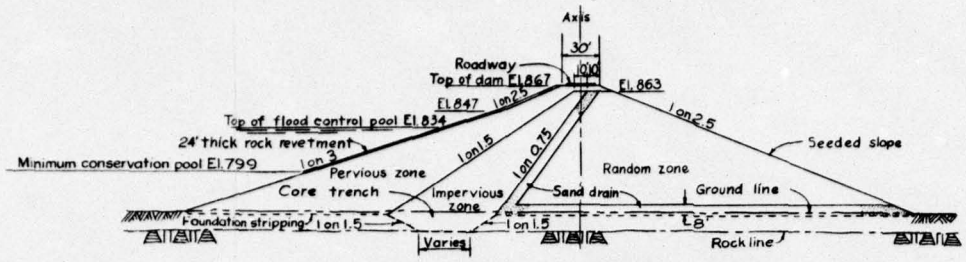








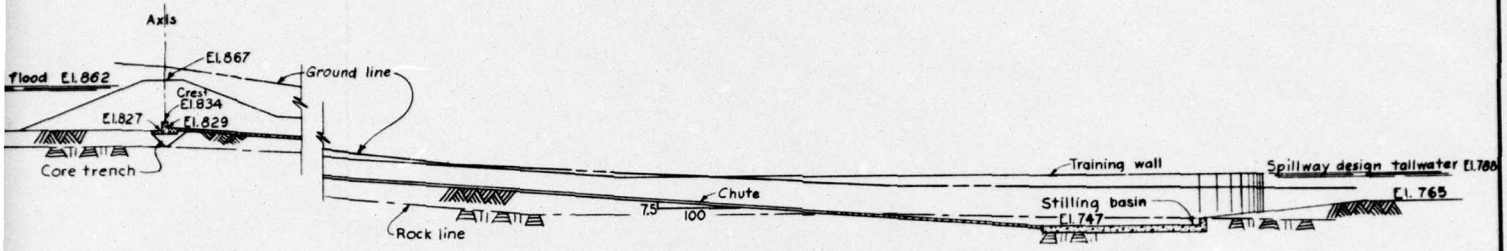
RESERVOIR



TYPICAL SECTION OF DAM

SCALE IN FEET

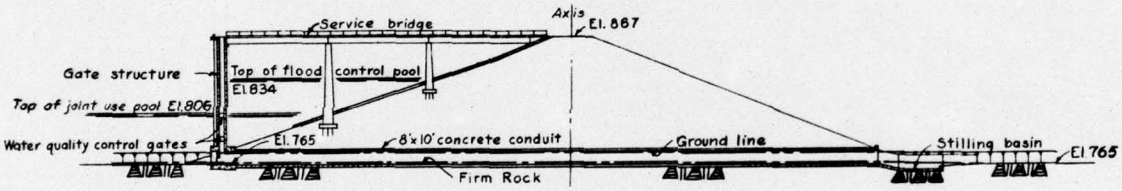
50 0 50 100



PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET

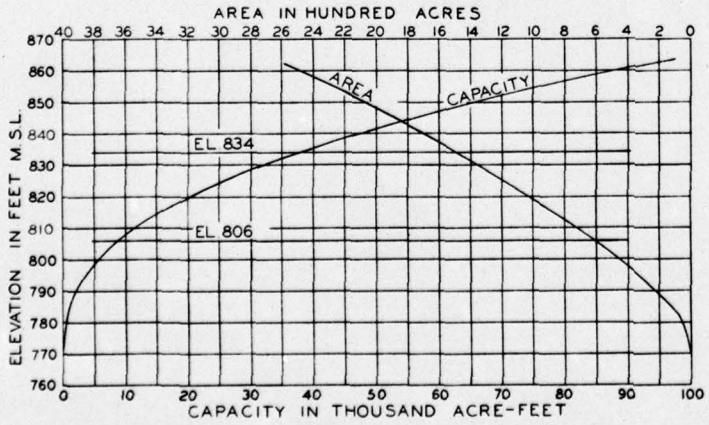
50 0 50 100



SECTION THRU OUTLET WORKS

SCALE IN FEET

50 0 50 100



RESERVOIR AREA AND CAPACITY CURVES

ELEVATION IN FEET M.S.L.

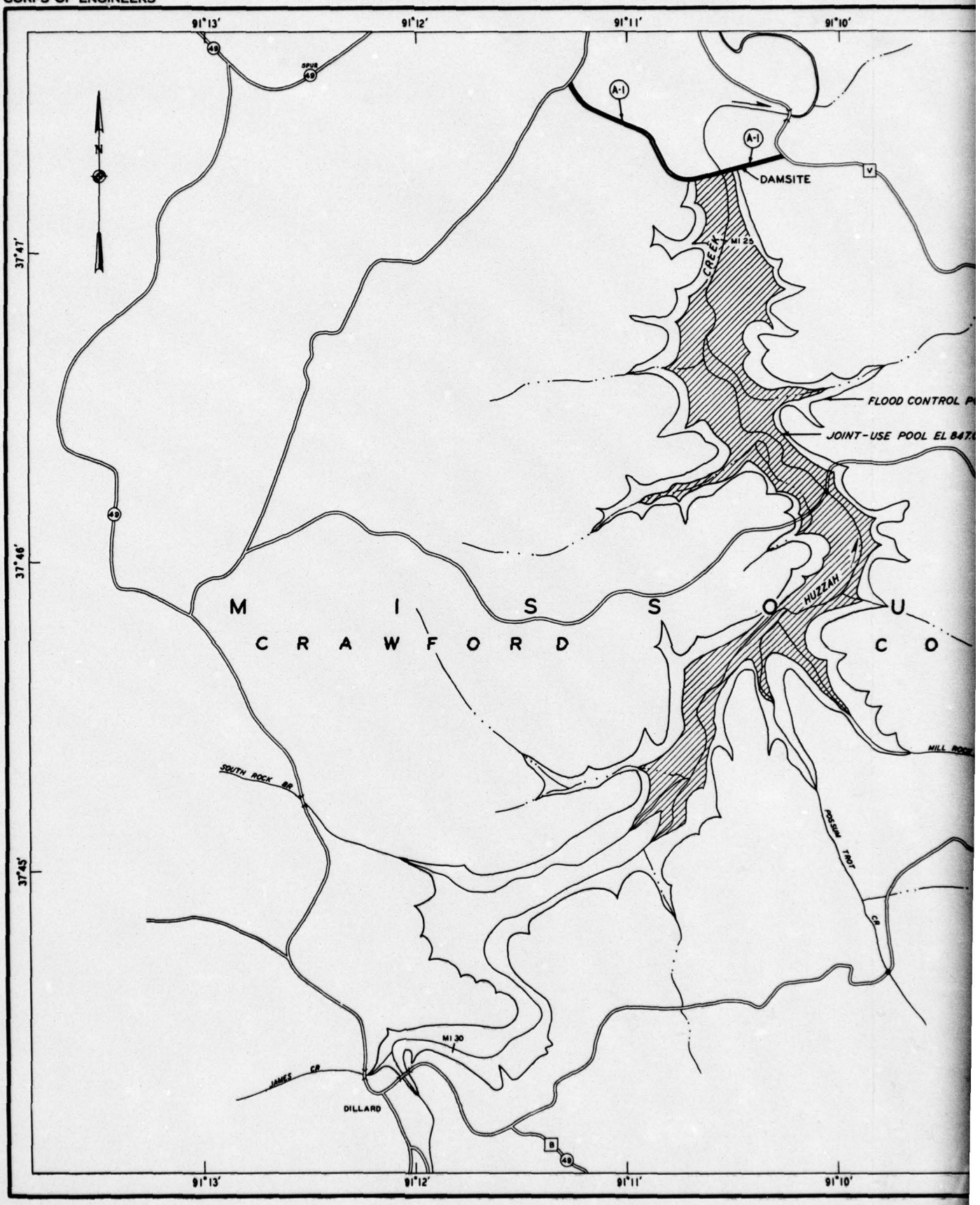
MERAMEC RIVER BASIN, MISSOURI
COURTOIS CREEK
DAM I-15A
DESIGN DETAILS

IN 1 SHEET SCALE AS SHOWN SHEET NO. 1

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-21

CORPS OF ENGINEERS



U. S. ARMY

91°11′ 91°10′ 91°09′ 91°08′ 91°07′

37°47′ 37°46′ 37°45′

VICINITY MAP

SCALE IN MILES

17 0 17 34

A-1 DAMSITE

V

CREEK

MI 25

FLOOD CONTROL POOL EL 881.0

JOINT-USE POOL EL 847.0

HUZZAH

S O U R I

C O U N T Y

MILL ROCK CR

POSSUM TROT

CR

LEGEND

A-1 ACCESS ROAD

RELOCATION OF EXISTING ROAD OR ACCESS ROAD TO DAM

EXISTING BRIDGE

EXISTING LOW WATER CROSSING

MERAMEC RIVER BASIN, MISSOURI

HUZZAH CREEK

RESERVOIR I-14

RESERVOIR MAP

IN 1 SHEET SHEET NO. 1

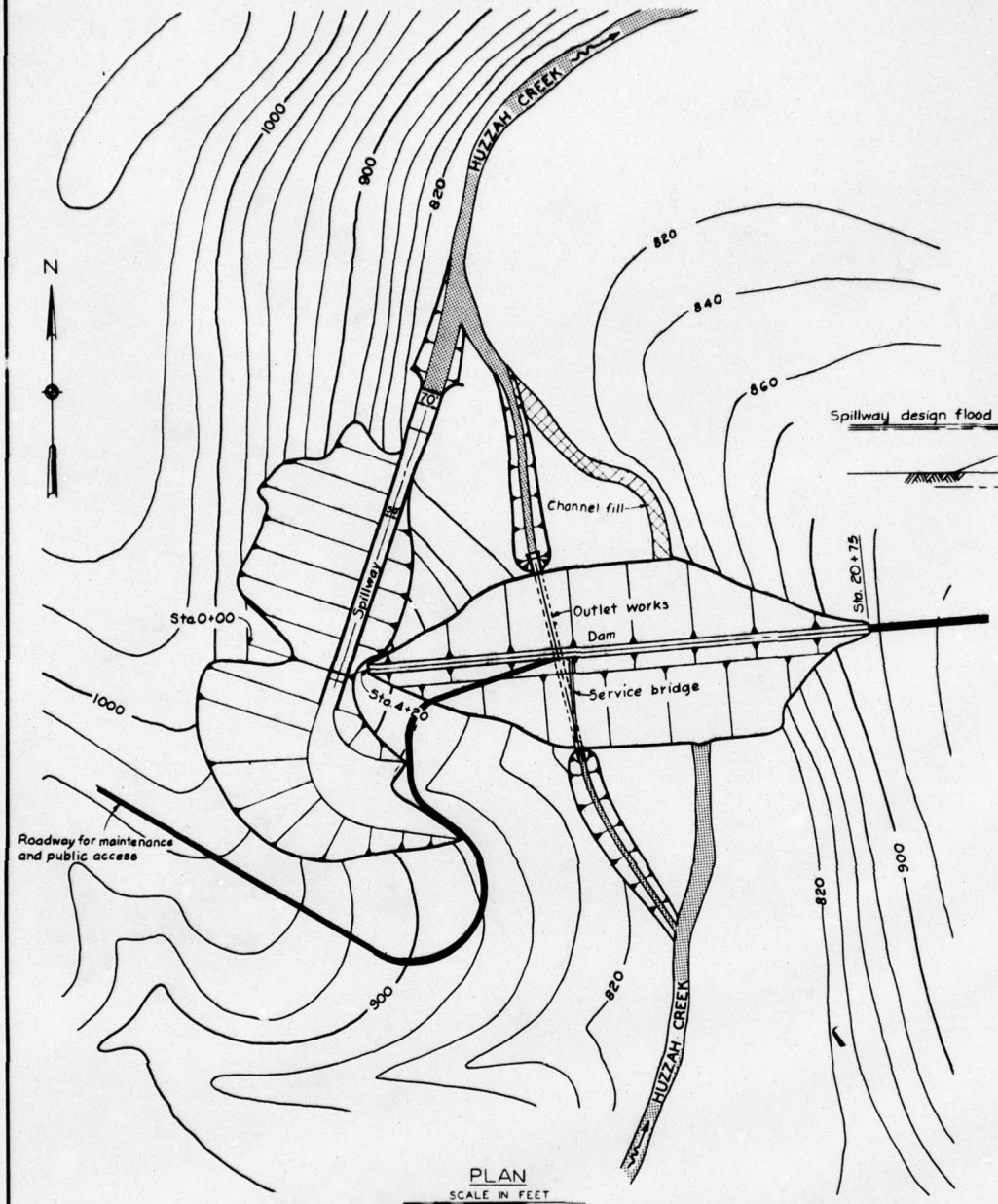
SCALE IN FEET

1000 0 1000 2000 3000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-22

CORPS OF ENGINEERS

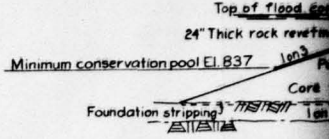


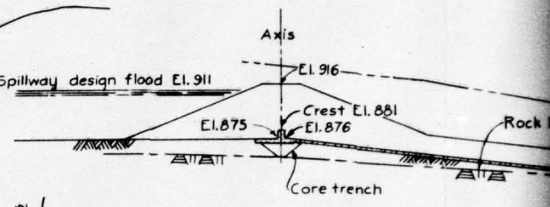
PLAN

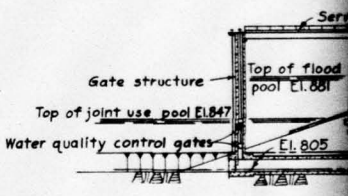
SCALE IN FEET

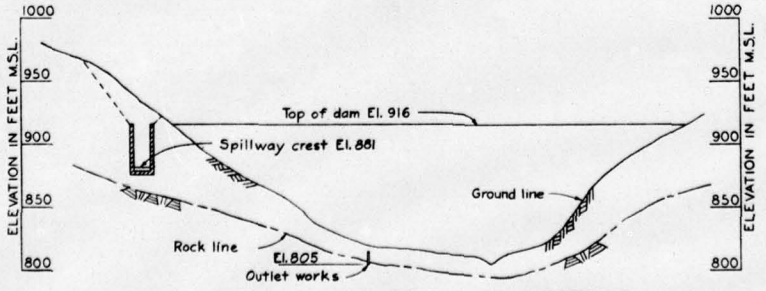
200 0 200 400

CONTOUR INTERVAL 20 FEET





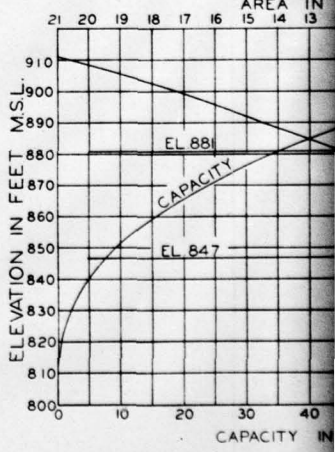




PROFILE ALONG AXIS LOOKING DOWNSTREAM

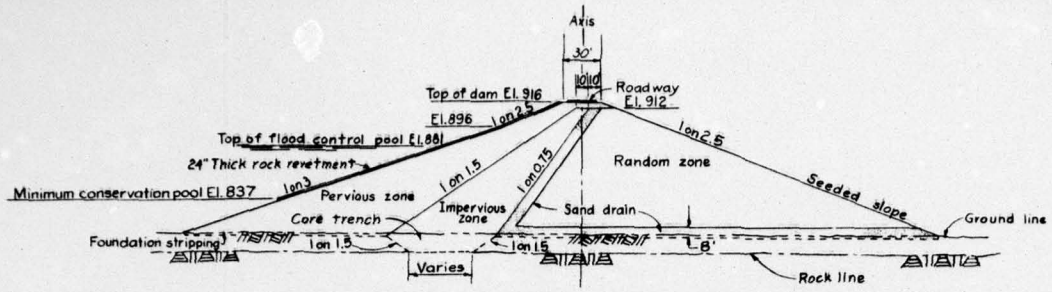
HORIZONTAL SCALE IN FEET

200 0 200 400



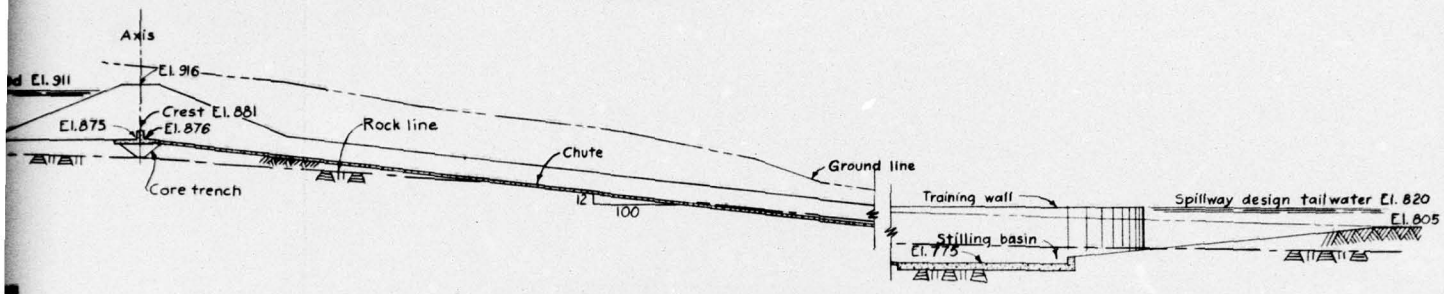
RESERVOIR AREA

2



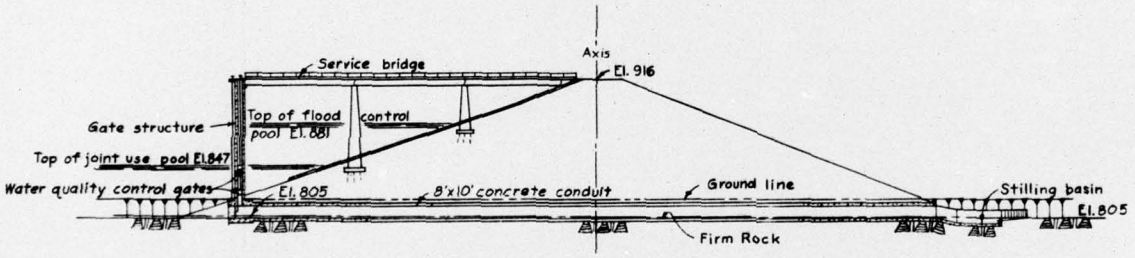
TYPICAL SECTION OF DAM

SCALE IN FEET
50 0 50 100



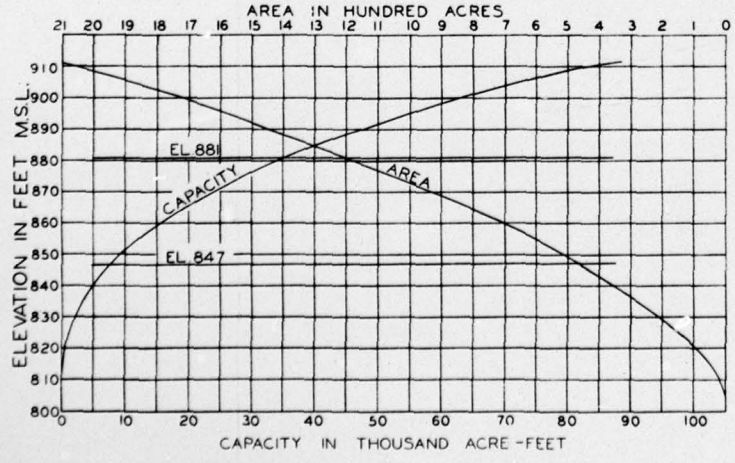
PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET
50 0 50 100



SECTION THRU OUTLET WORKS

SCALE IN FEET
50 0 50 100



RESERVOIR AREA AND CAPACITY CURVES

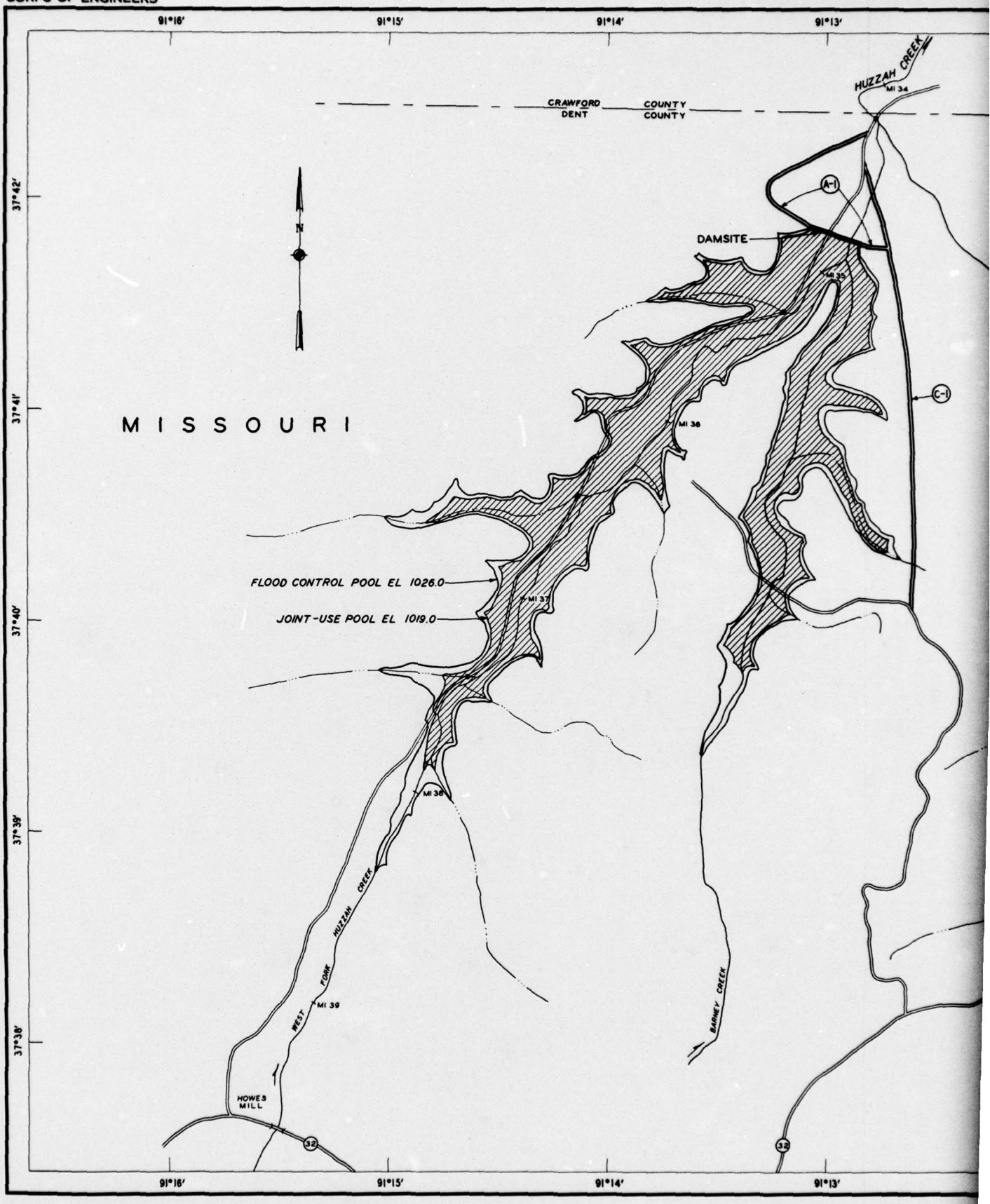
MERAMEC RIVER BASIN, MISSOURI
HUZZAH CREEK
DAM I-14
DESIGN DETAILS

IN 1 SHEET — SCALE AS SHOWN — SHEET NO. 1

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-23

CORPS OF ENGINEERS



U. S. ARMY

2

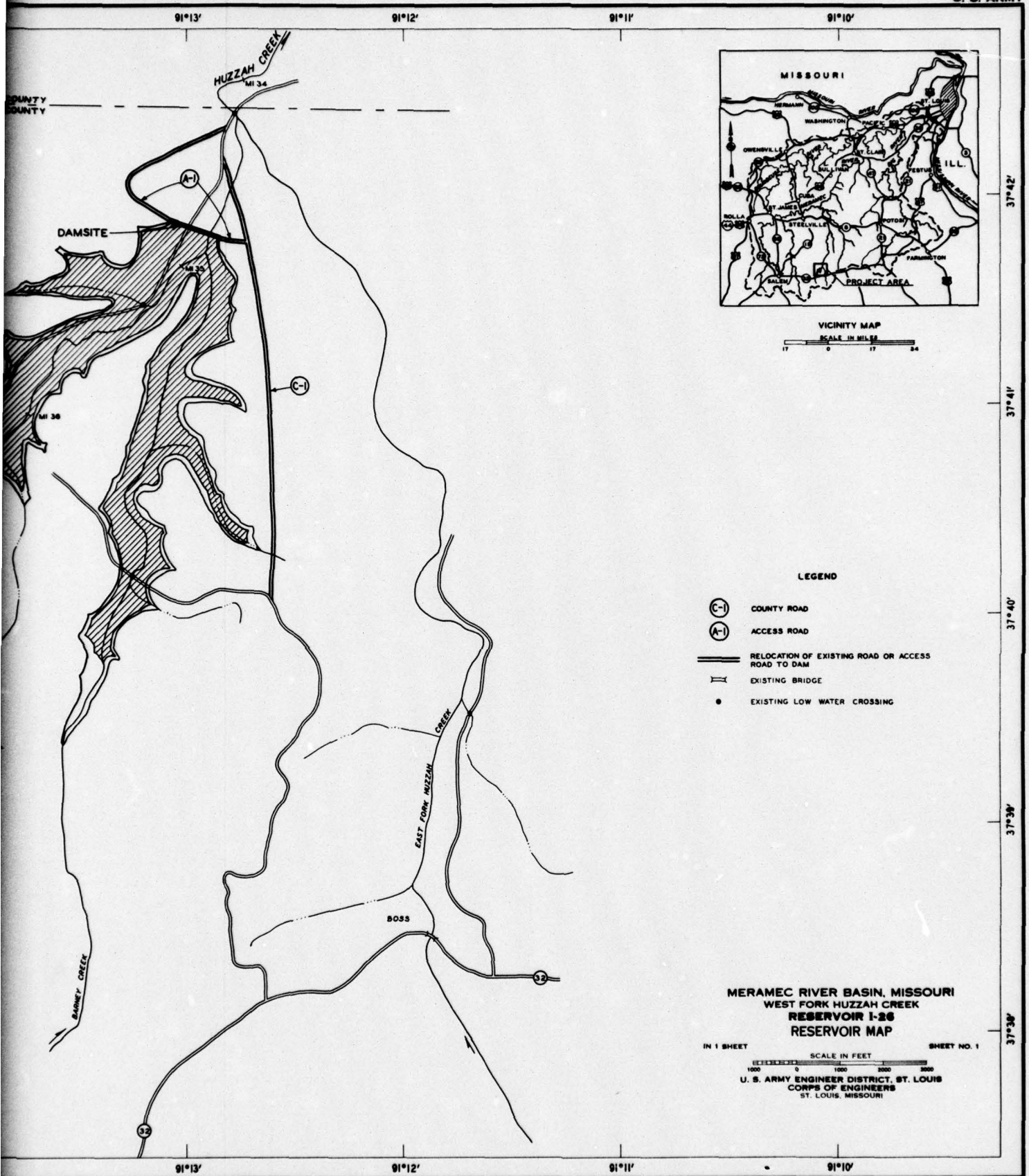
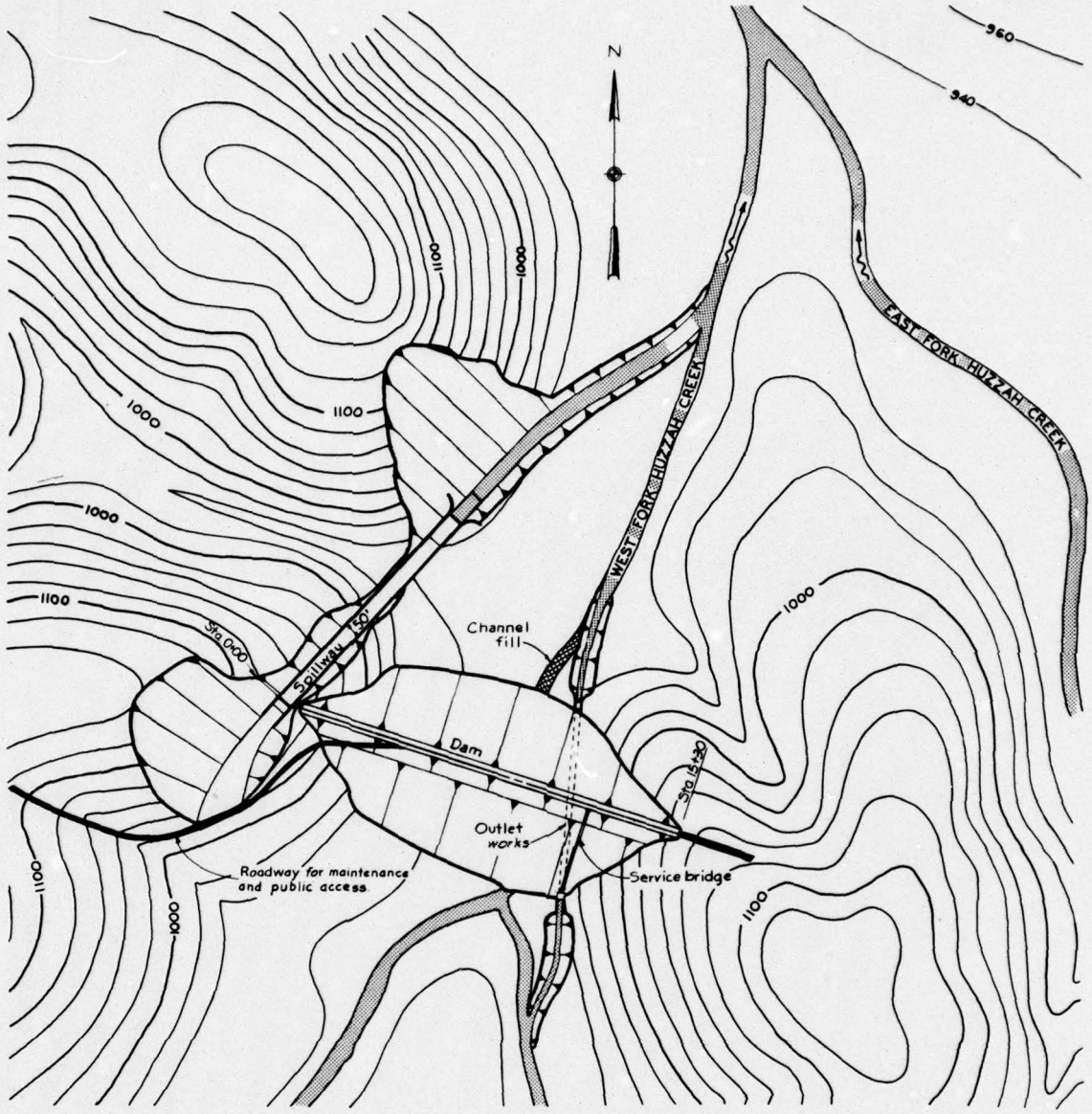
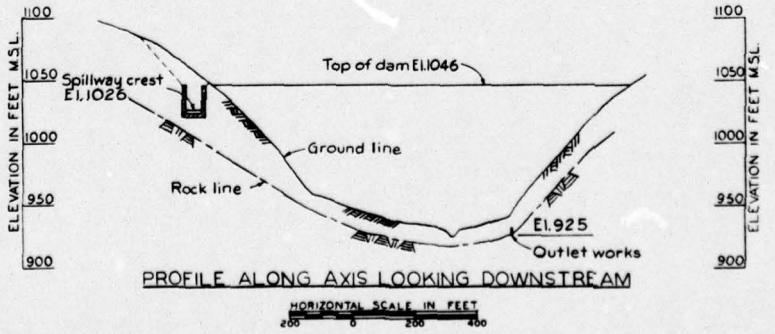


PLATE E-24

CORPS OF ENGINEERS



PLAN
SCALE IN FEET
200 0 200 400
CONTOUR INTERVAL 20 FEET



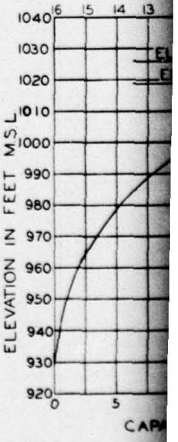
Minimum conservation pool E

Spillway design flood El. 1041

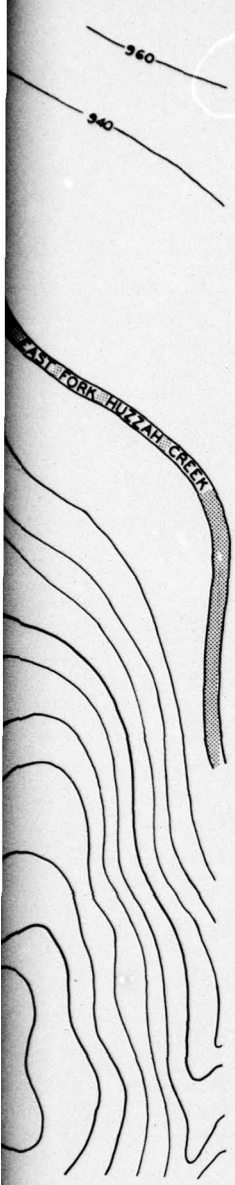
Core trench

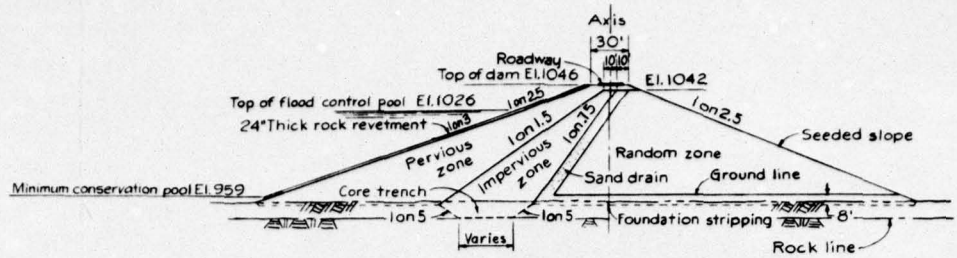
Water quality control gates

Gate structure



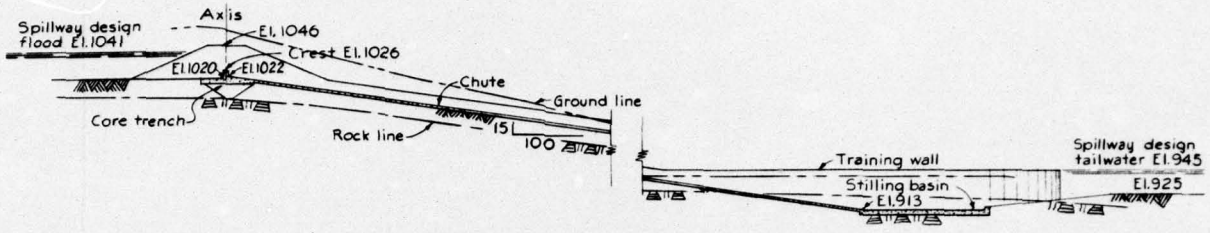
RESERVO





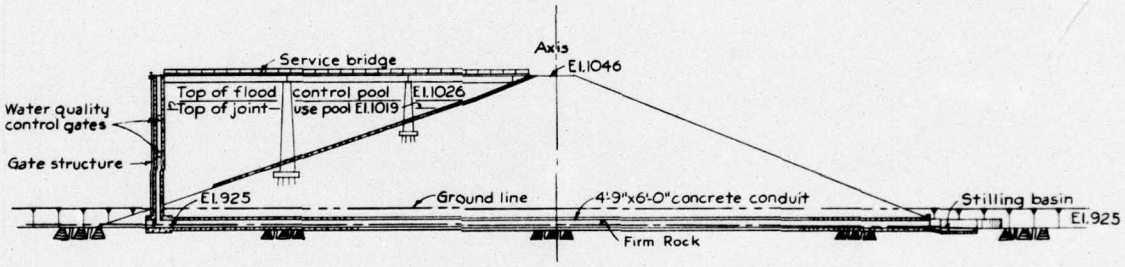
TYPICAL SECTION OF DAM

SCALE IN FEET
50 0 50 100



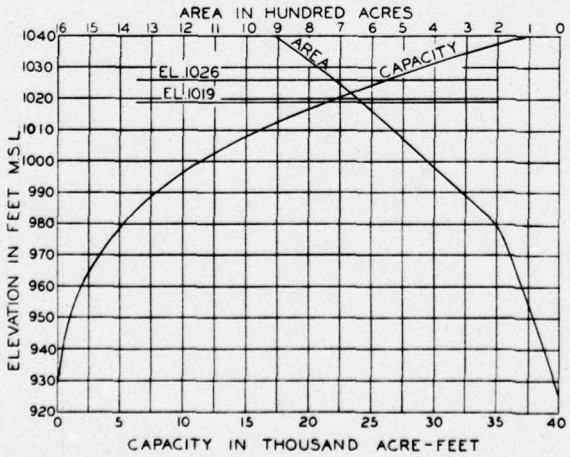
PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET
50 0 50 100



SECTION THRU OUTLET WORKS

SCALE IN FEET
50 0 50 100



RESERVOIR AREA AND CAPACITY CURVES

ELEVATION IN FEET M.S.L.

MERAMEC RIVER BASIN, MISSOURI
WEST FORK HUZZAH CREEK
DAM 1-26
DESIGN DETAILS

IN 1 SHEET SHEET NO. 1

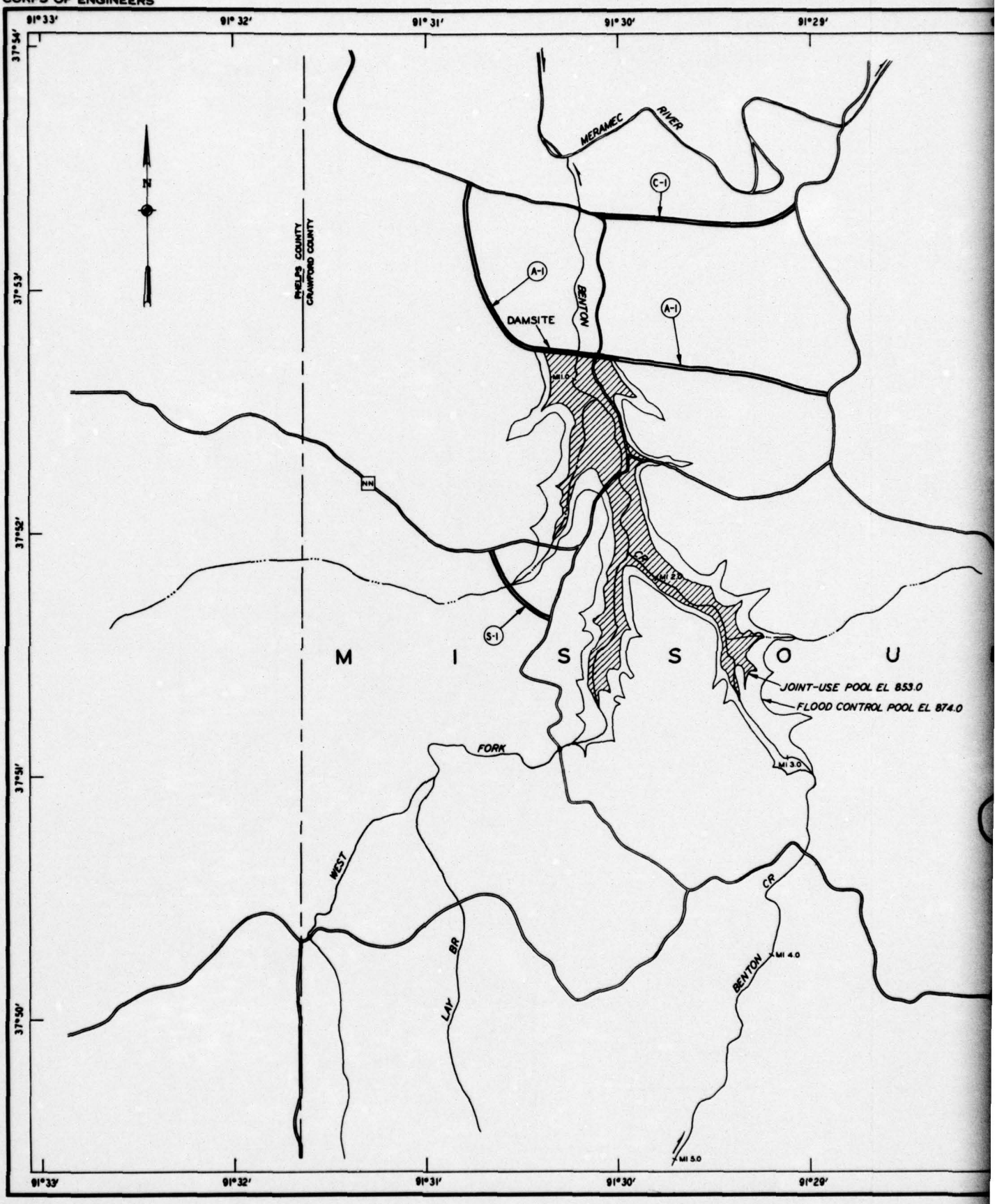
SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS MISSOURI

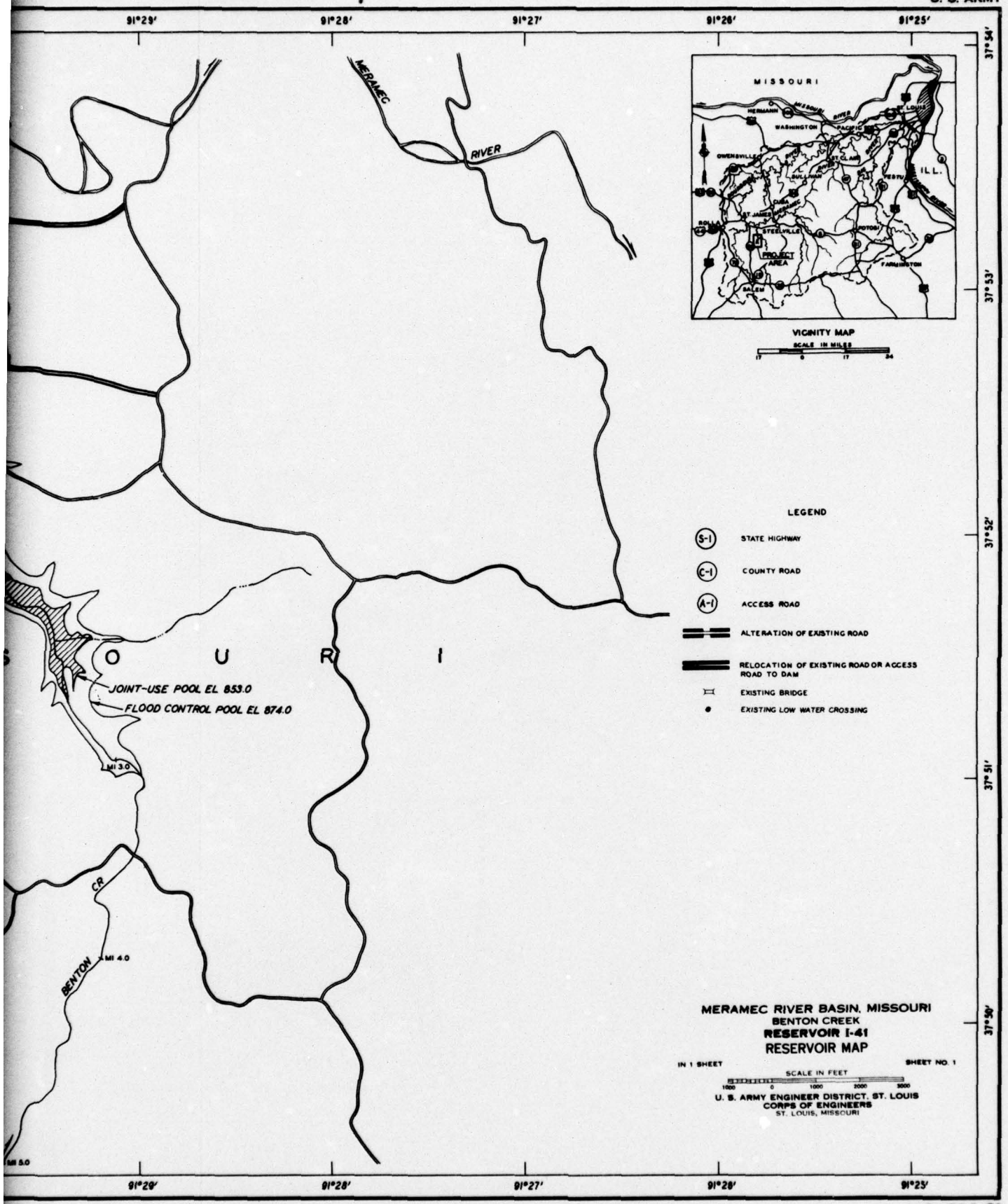
R Apr 64

PLATE E-25

CORPS OF ENGINEERS



U. S. ARMY



MERAMEC RIVER BASIN, MISSOURI
BENTON CREEK
RESERVOIR I-41
RESERVOIR MAP

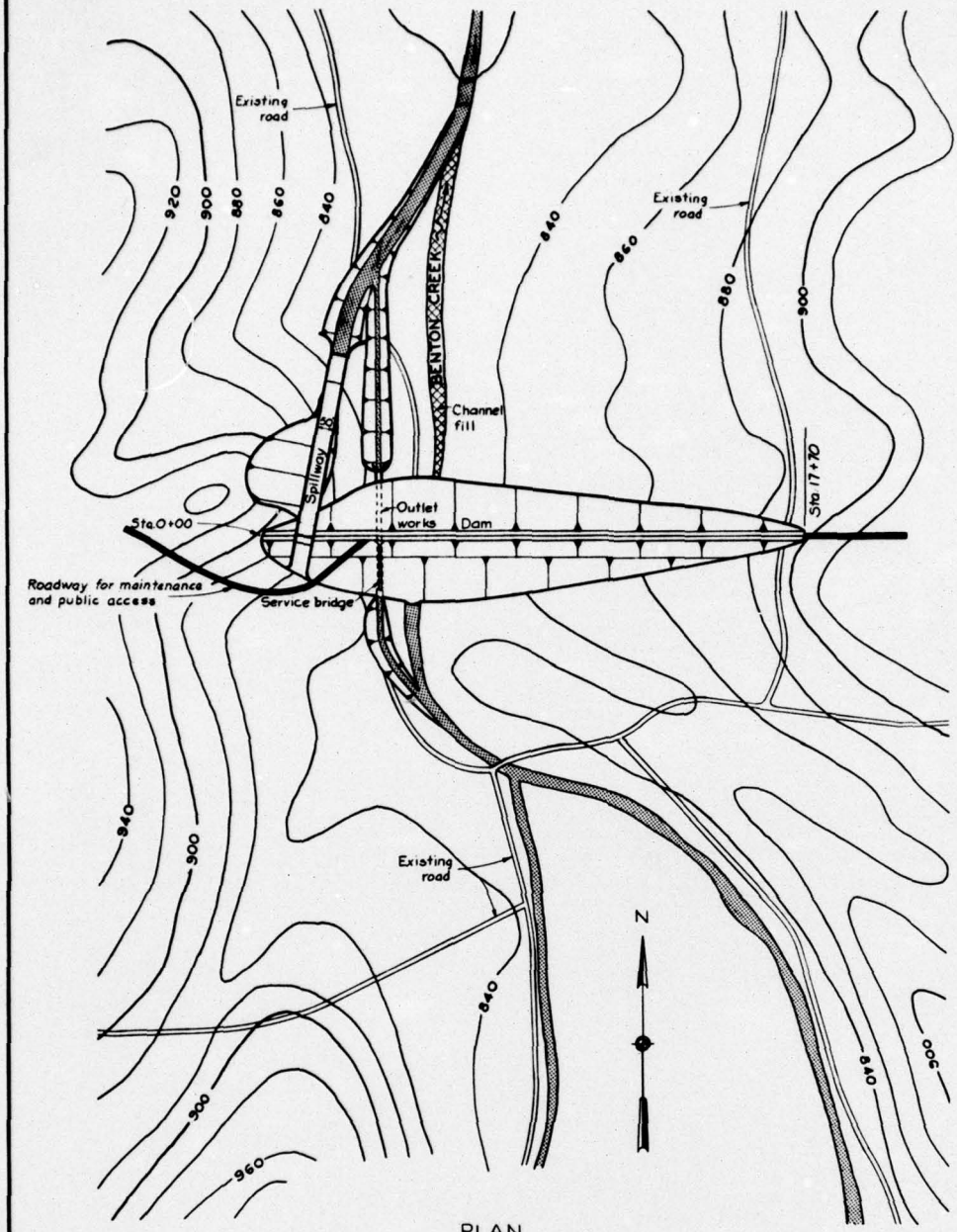
IN 1 SHEET SHEET NO. 1

SCALE IN FEET
1000 0 1000 2000 3000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-26

CORPS OF ENGINEERS

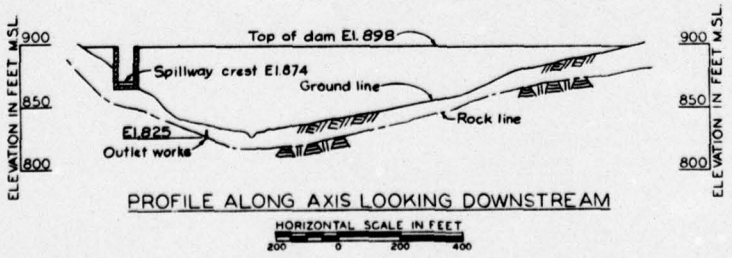


PLAN

SCALE IN FEET

200 0 200 400

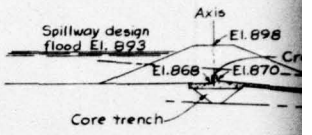
CONTOUR INTERVAL 20 FEET

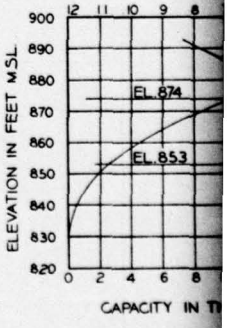


PROFILE ALONG AXIS LOOKING DOWNSTREAM

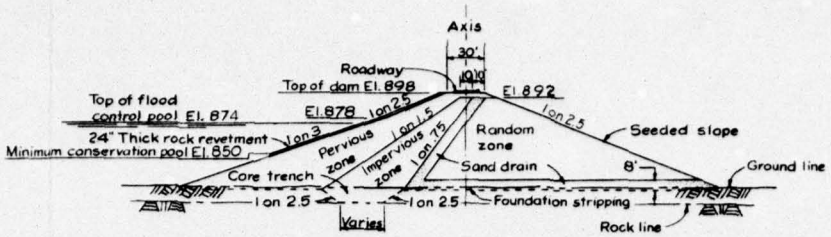
HORIZONTAL SCALE IN FEET

200 0 200 400





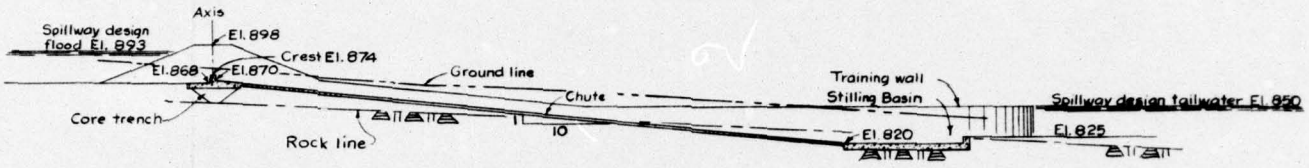
RESERVOIR AREA



TYPICAL SECTION OF DAM

SCALE IN FEET

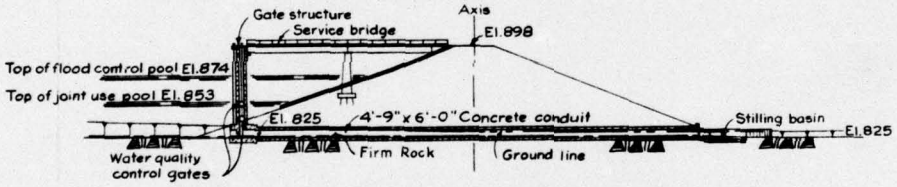
50 0 50 100



PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET

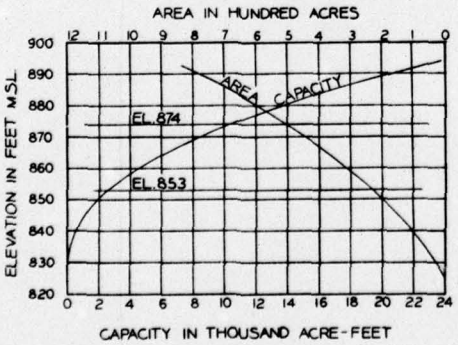
50 0 50 100



SECTION THRU OUTLET WORKS

SCALE IN FEET

50 0 50 100



RESERVOIR AREA AND CAPACITY CURVES

MERAMEC RIVER BASIN, MISSOURI
BENTON CREEK
DAM I-41
DESIGN DETAILS

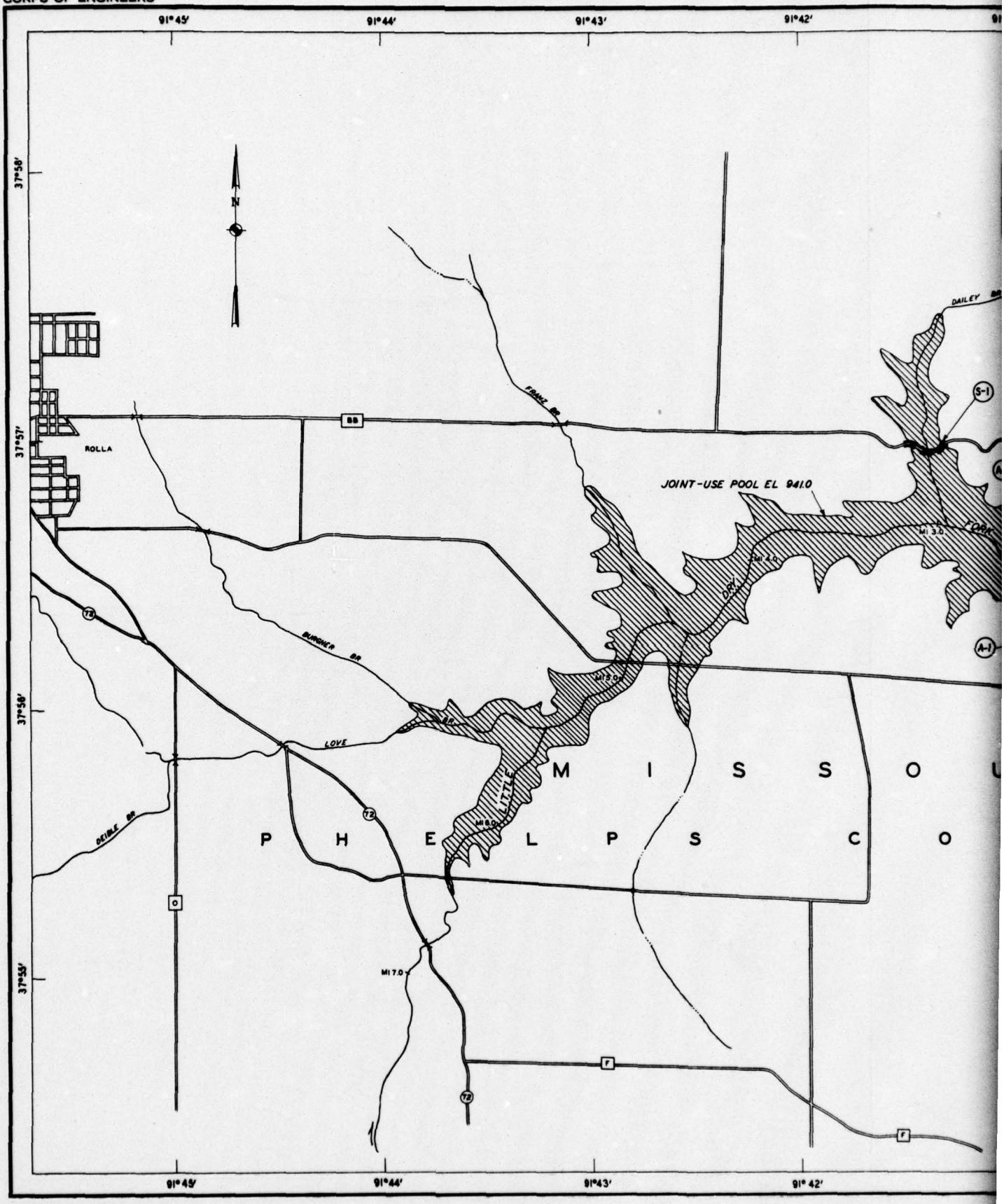
IN 1 SHEET SHEET NO. 1

SCALE AS SHOWN

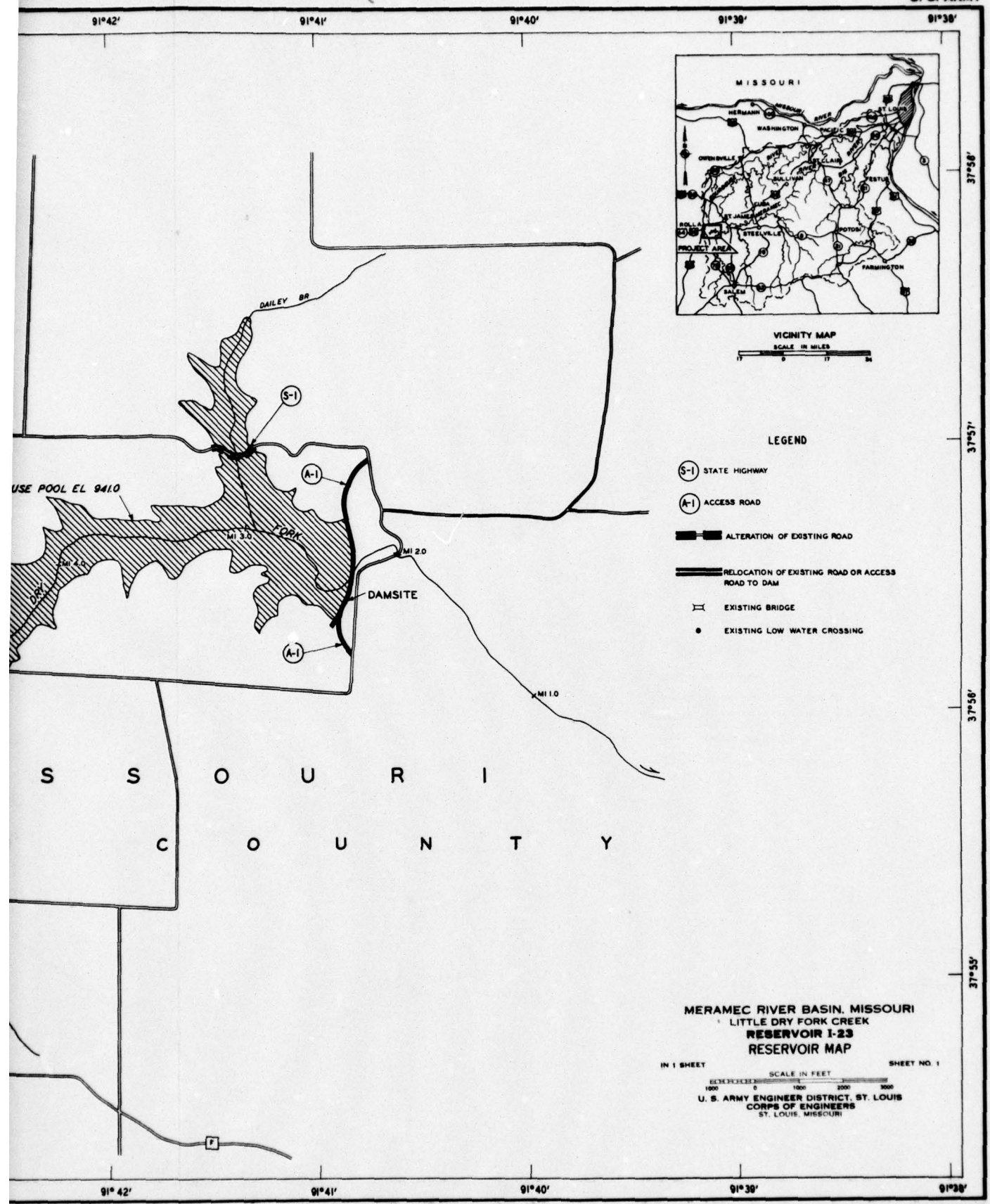
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-27

CORPS OF ENGINEERS



U. S. ARMY



MERAMEC RIVER BASIN, MISSOURI
LITTLE DRY FORK CREEK
RESERVOIR I-23
RESERVOIR MAP

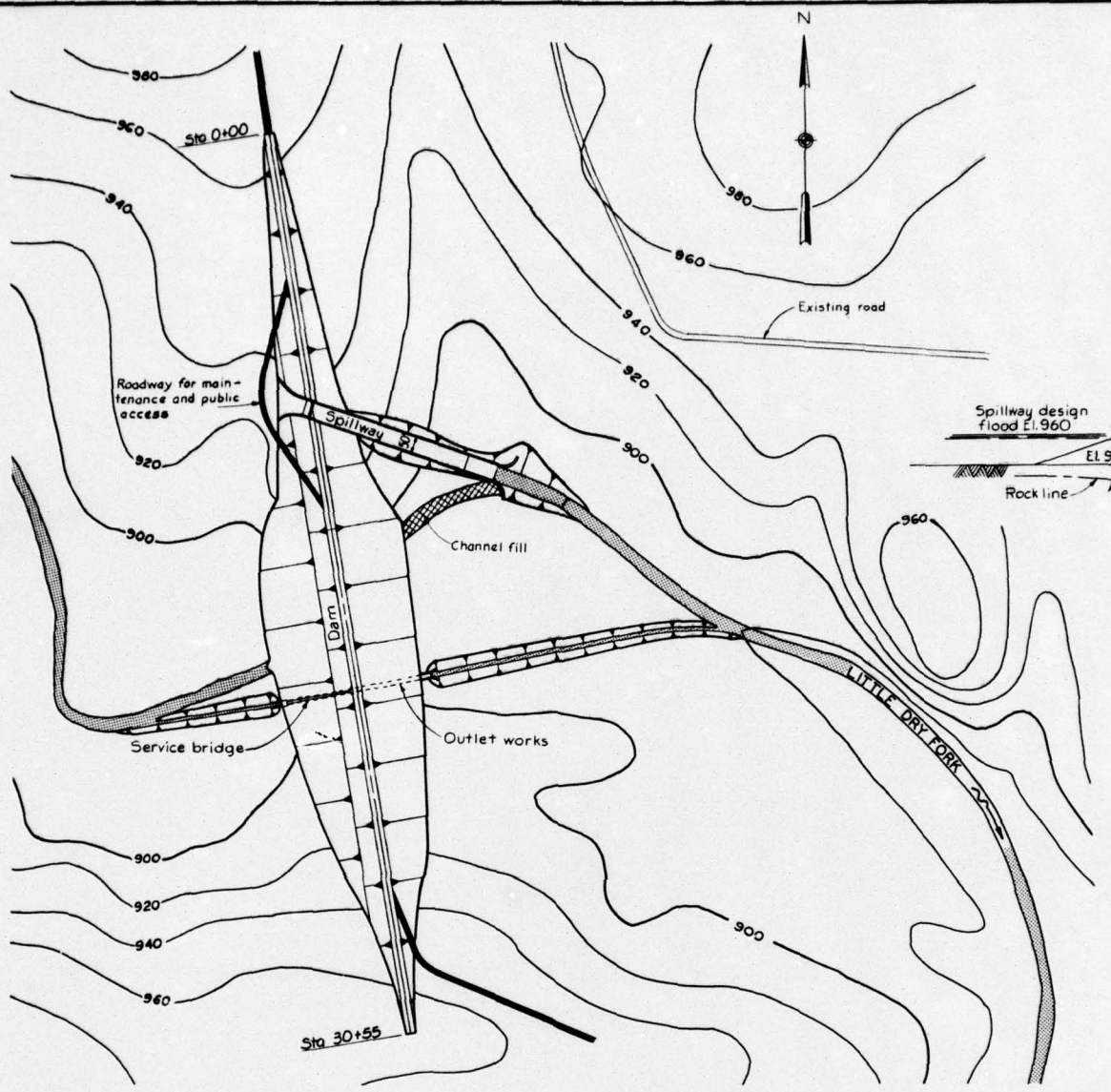
IN 1 SHEET SHEET NO. 1

SCALE IN FEET
1000 0 1000 2000 3000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-28

CORPS OF ENGINEERS

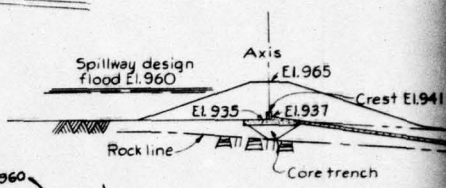


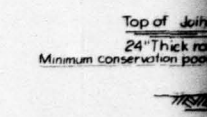
PLAN

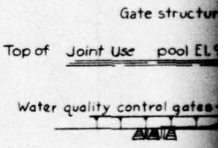
SCALE IN FEET

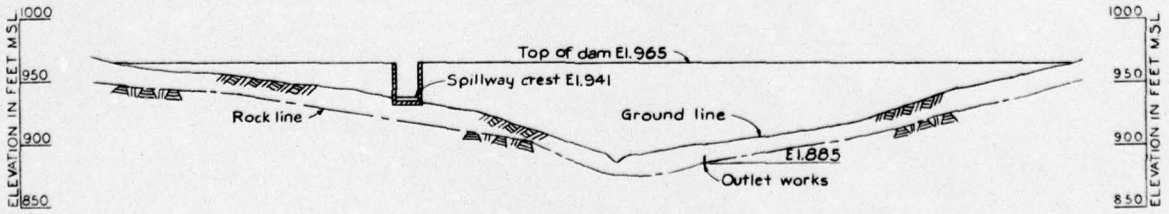
200 0 200 400

CONTOUR INTERVAL 20 FEET





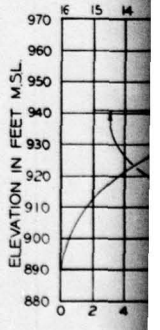




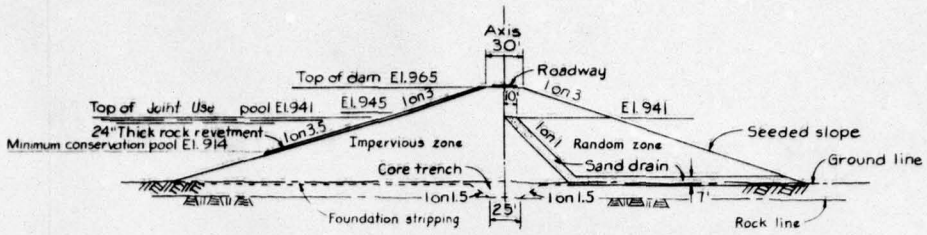
PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONTAL SCALE IN FEET

200 0 200 400



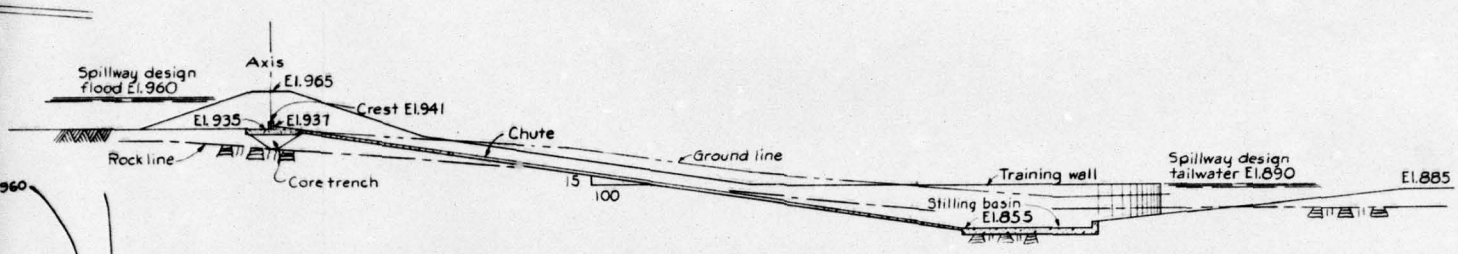
RESERV



TYPICAL SECTION OF DAM

SCALE IN FEET

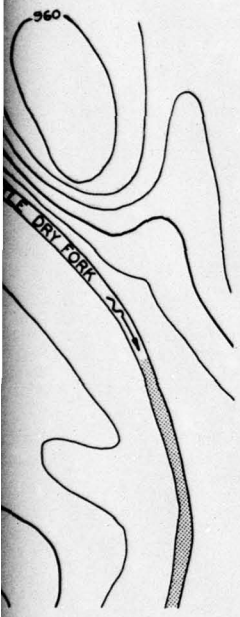
50 0 50 100

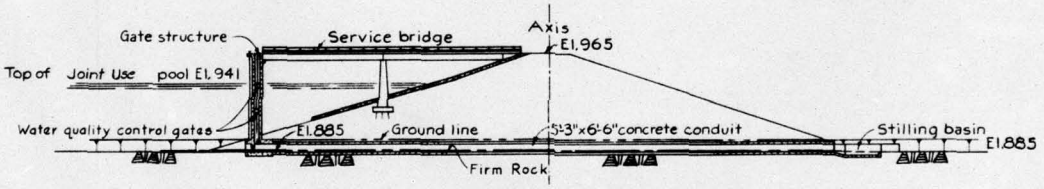


PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET

50 0 50 100

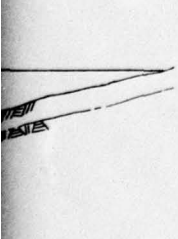


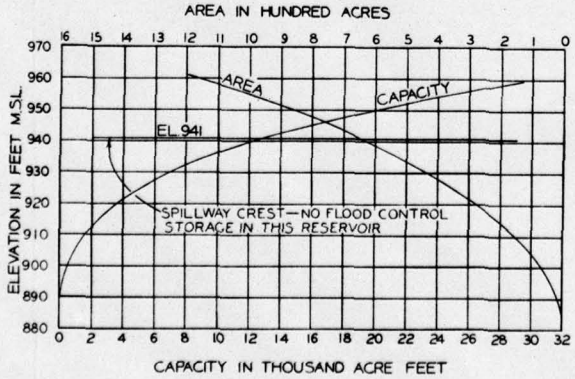


SECTION THRU OUTLET WORKS

SCALE IN FEET

50 0 50 100





RESERVOIR AREA AND CAPACITY CURVES

MERAMEC RIVER BASIN, MISSOURI
LITTLE DRY FORK CREEK
DAM 1-23
DESIGN DETAILS

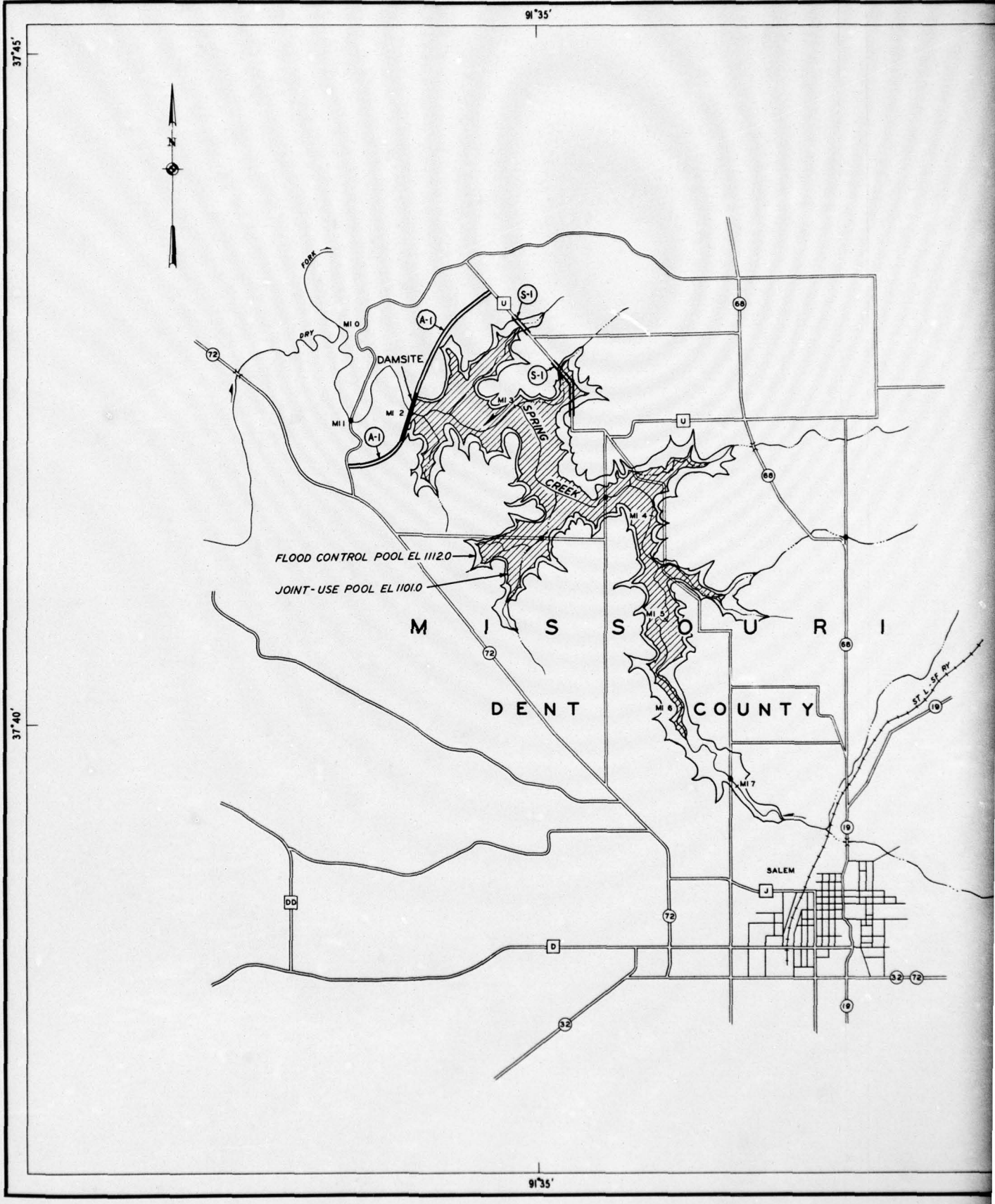
IN 1 SHEET SHEET NO. 1

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

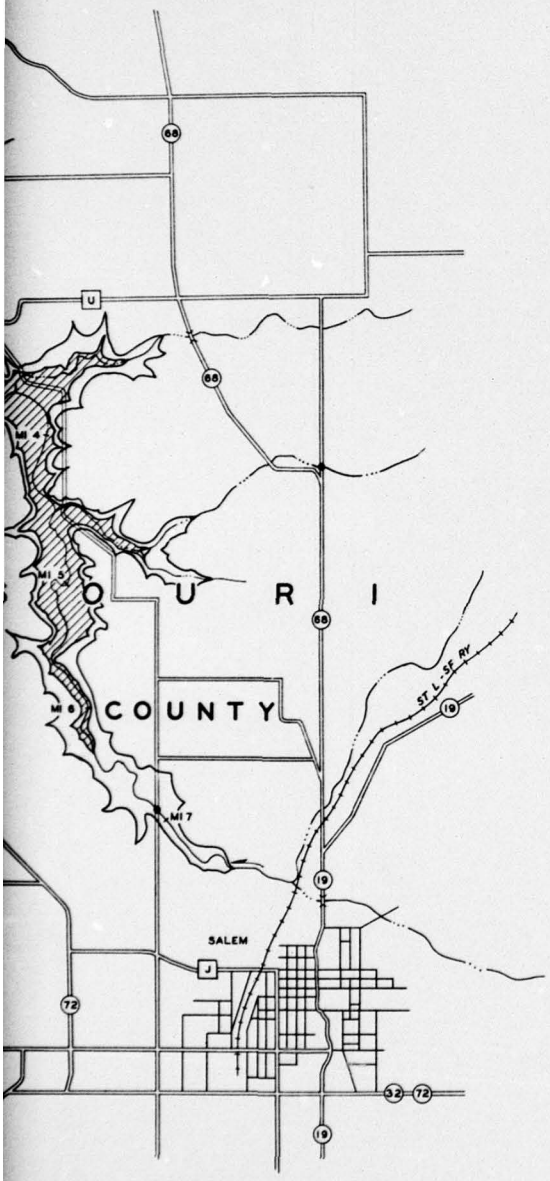
PLATE E-29

CORPS OF ENGINEERS



U. S. ARMY

91°30′ 91°25′ 37°45′ 37°40′



VICINITY MAP

SCALE IN MILES

17 0 17 34

LEGEND

- (S-1) STATE HIGHWAY
- (A-1) ACCESS ROAD
- ALTERATION OF EXISTING ROAD
- RELOCATION OF EXISTING ROAD OR ACCESS ROAD TO DAM
- EXISTING BRIDGE
- EXISTING LOW WATER CROSSING

MERAMEC RIVER BASIN, MISSOURI

SPRING CREEK

RESERVOIR I-28

RESERVOIR MAP

IN 1 SHEET SHEET NO. 1

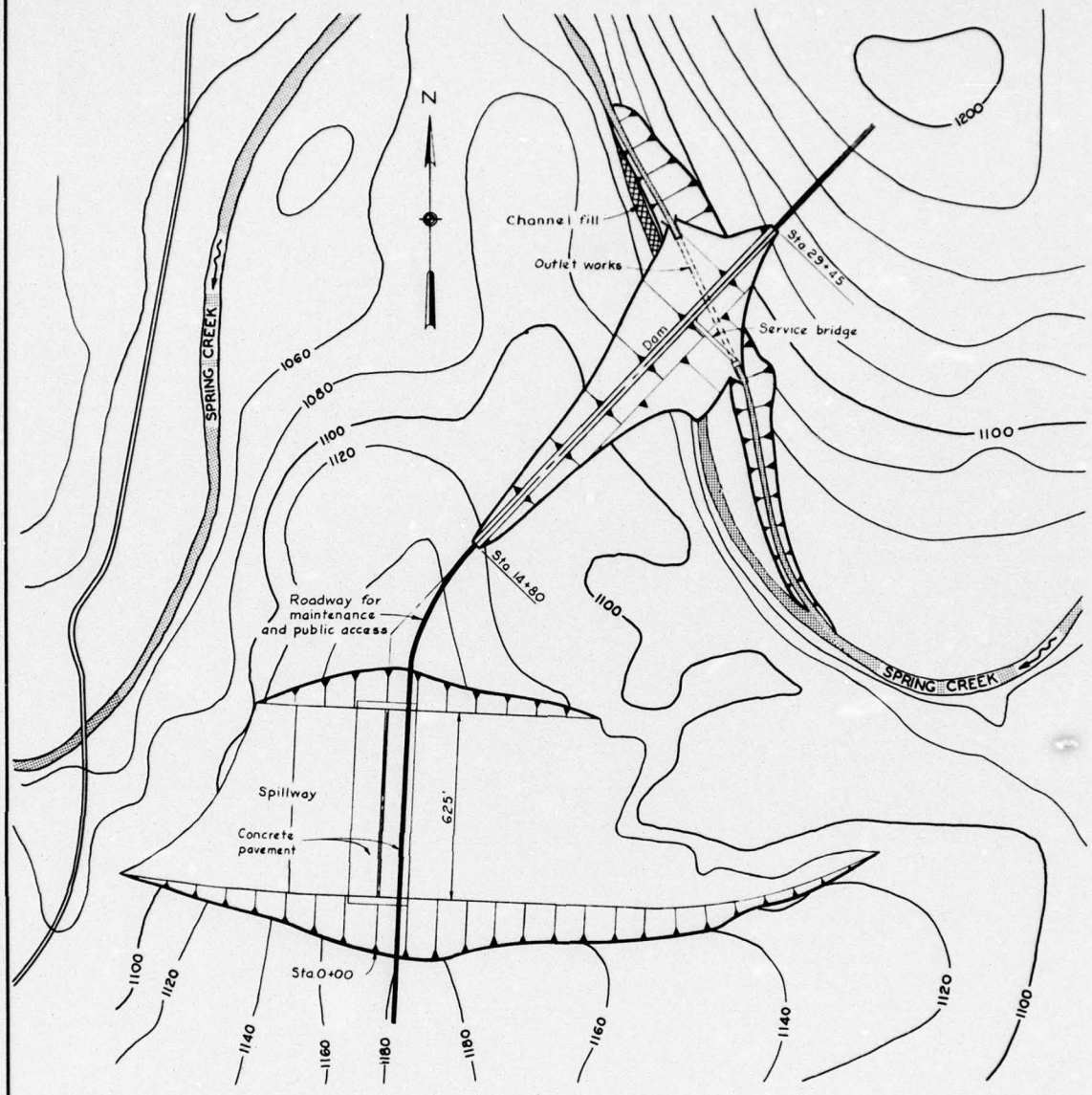
SCALE IN FEET

2000 0 2000 4000 6000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-30

CORPS OF ENGINEERS

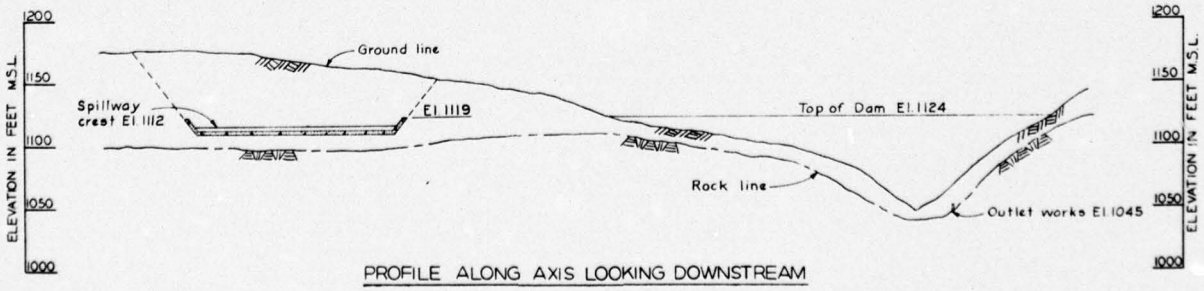


PLAN

SCALE IN FEET

200 0 200 400

CONTOUR INTERVAL 20 FEET



PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONAL SCALE IN FEET

200 0 200 400

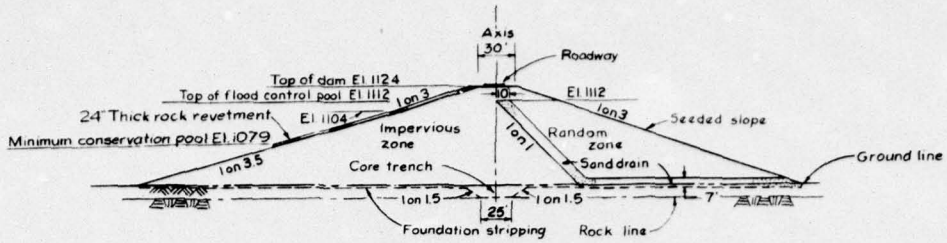
Minimum

ELEVATION IN FEET M.S.L.
1200
1150
1100
1050

Top of flood

Top of joint

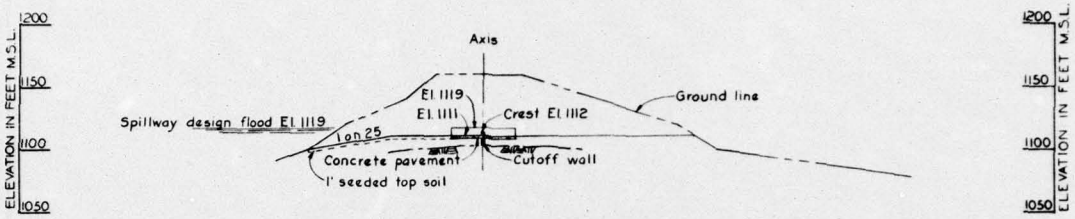
ELEVATION IN FEET M.S.L.
1130
1120
1110
1100
1090
1080
1070
1060
1050
1040
40 38
0



TYPICAL SECTION OF DAM

SCALE IN FEET

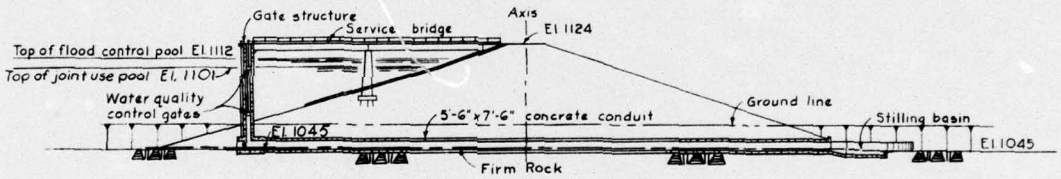
50 0 50 100



PROFILE ALONG ℄ SPILLWAY

HORIZONTAL SCALE IN FEET

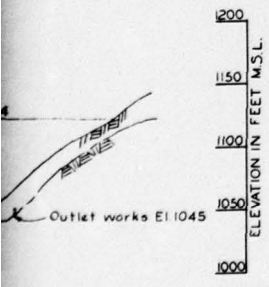
200 0 200 400

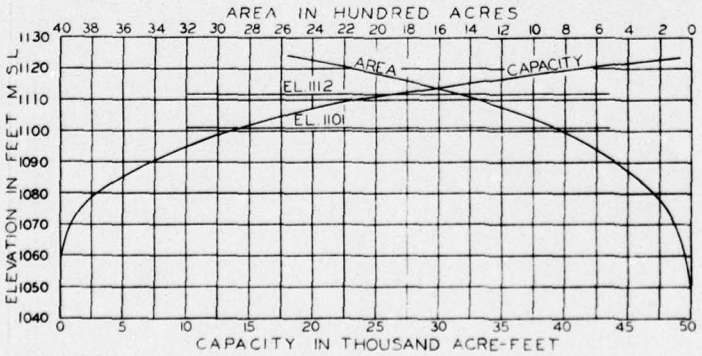


SECTION THRU OUTLET WORKS

SCALE IN FEET

50 0 50 100





RESERVOIR AREA AND CAPACITY CURVES

MERAMEC RIVER BASIN, MISSOURI
SPRING CREEK
DAM 1-28
DESIGN DETAILS

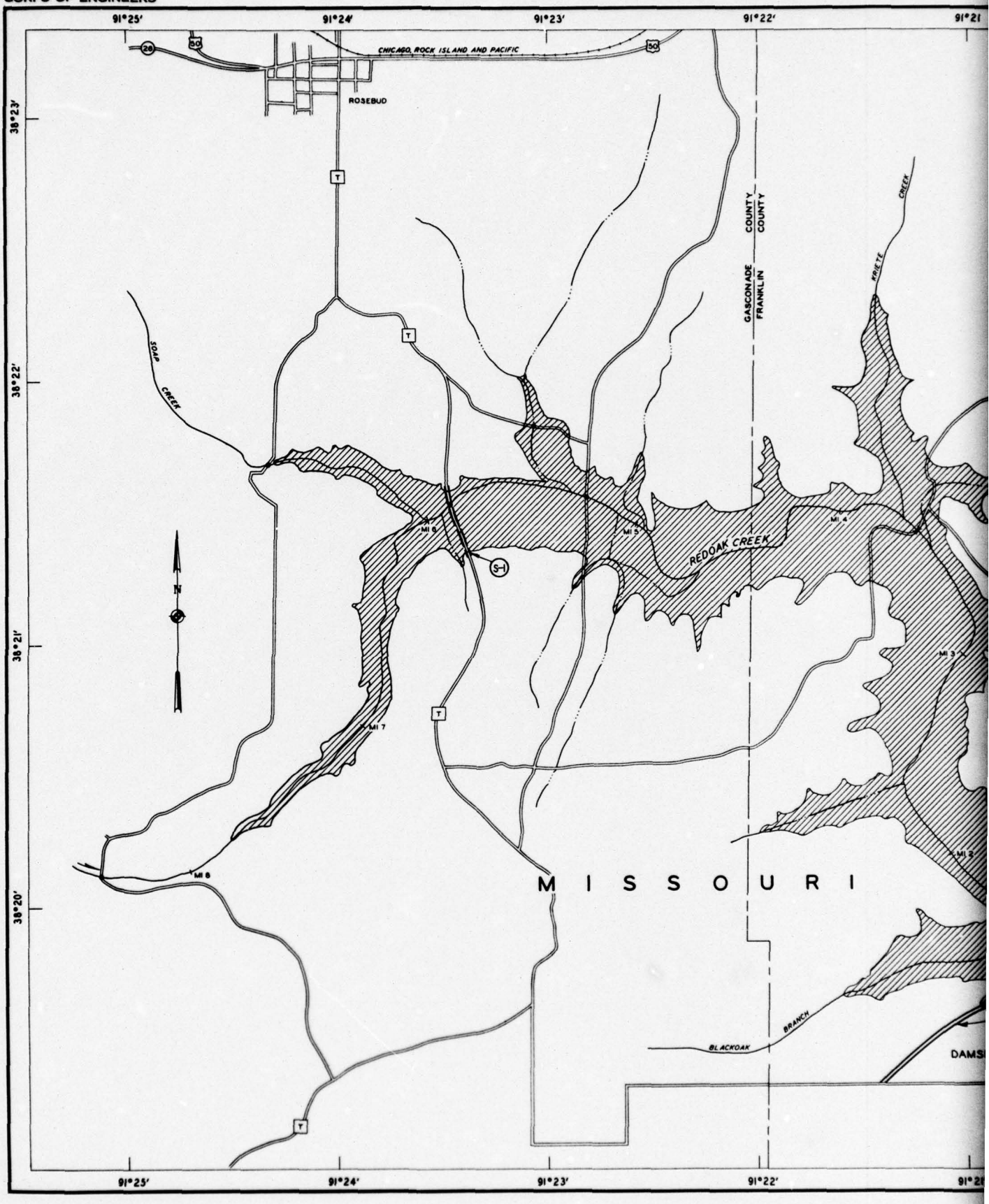
IN 1 SHEET SHEET NO. 1

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS MISSOURI

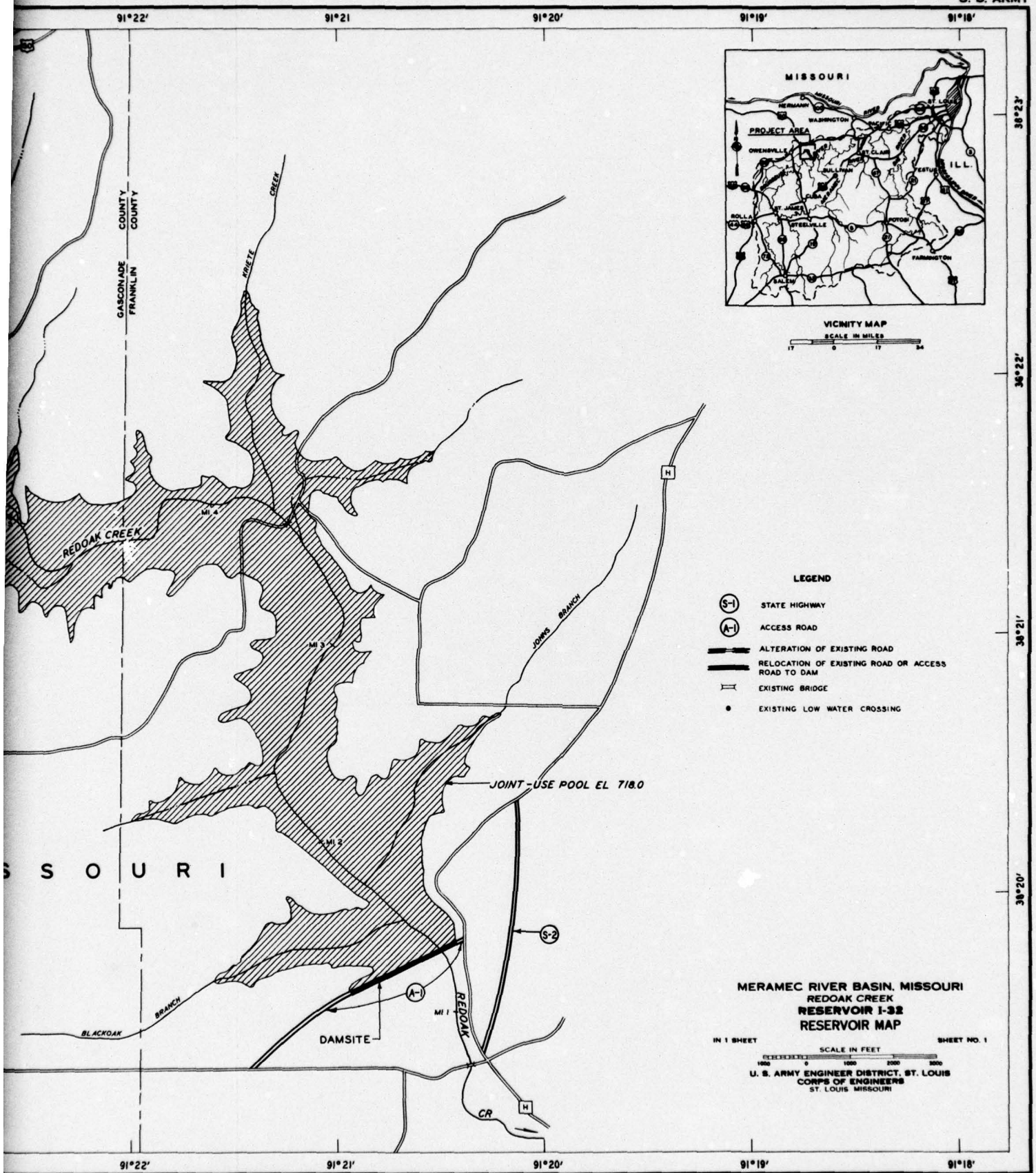
PLATE E-31

CORPS OF ENGINEERS



U. S. ARMY

2



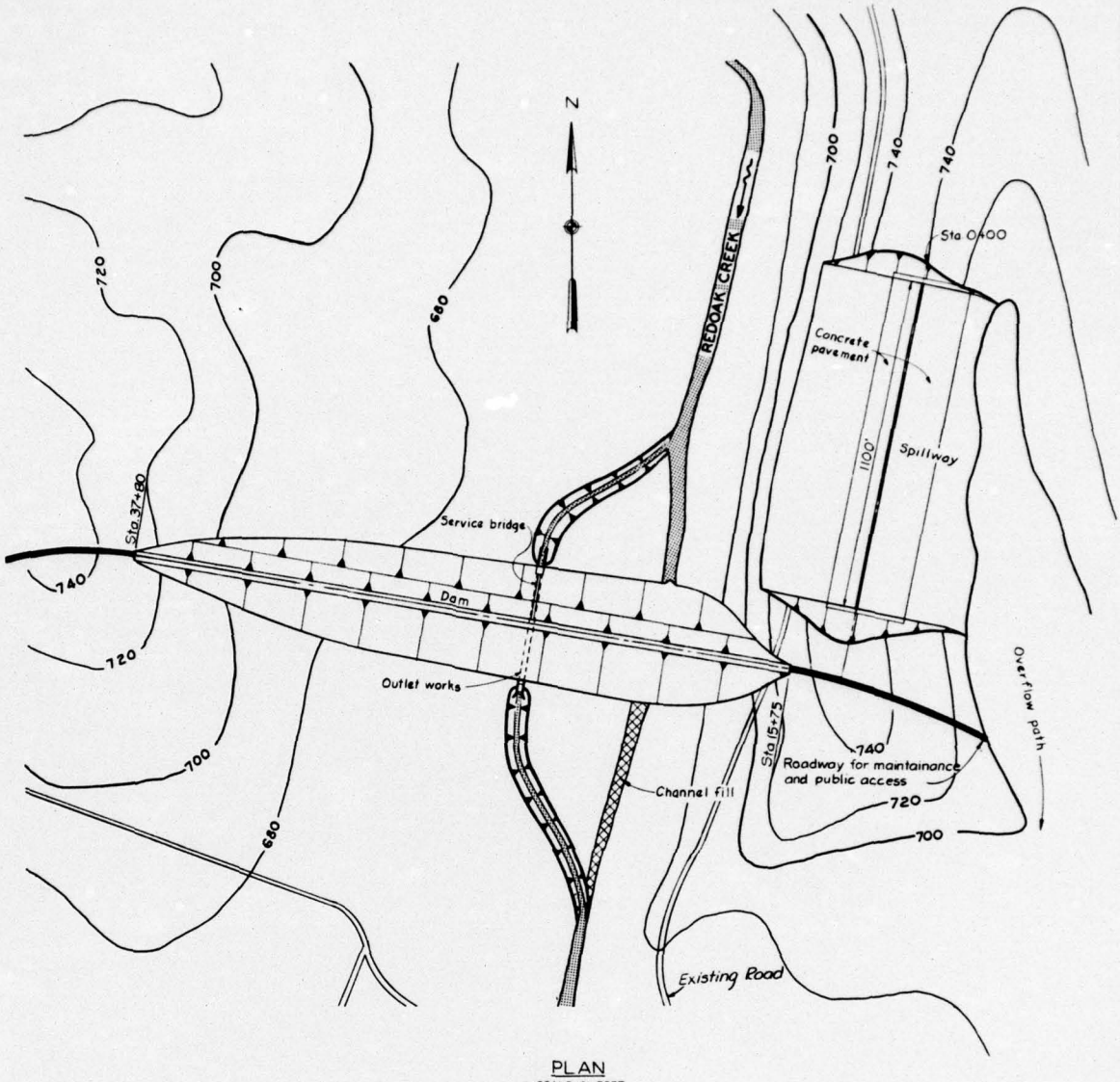
MERAMEC RIVER BASIN, MISSOURI
REDOAK CREEK
RESERVOIR I-32
RESERVOIR MAP

IN 1 SHEET SHEET NO. 1

SCALE IN FEET
1000 0 1000 2000 3000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS MISSOURI

PLATE E-32

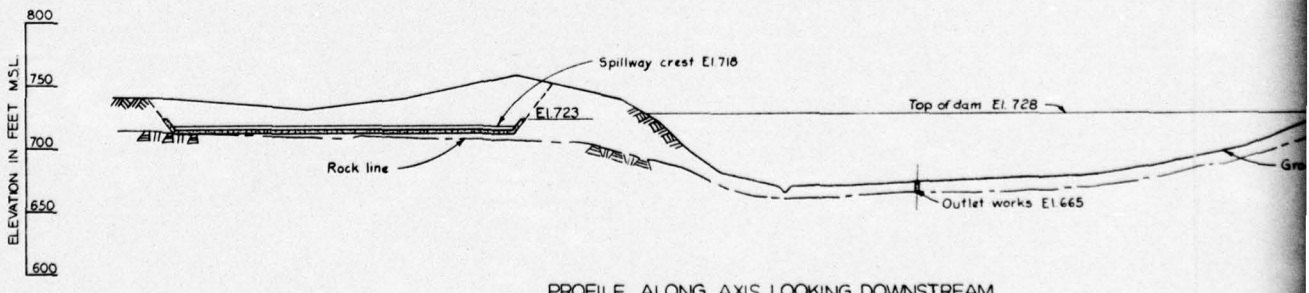


PLAN

SCALE IN FEET

200 0 200 400

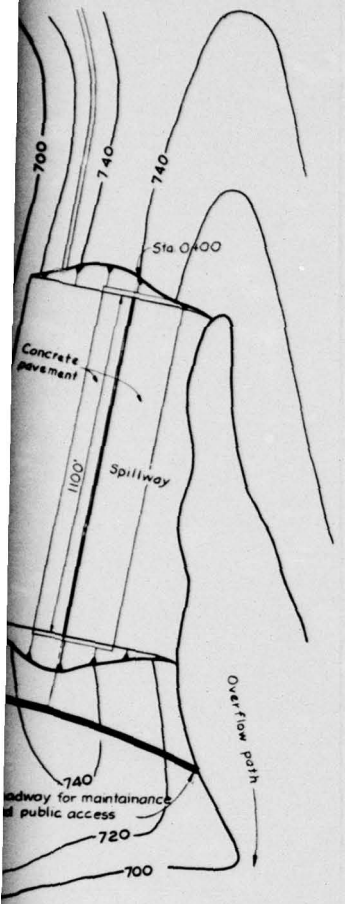
CONTOUR INTERVAL 20 FEET

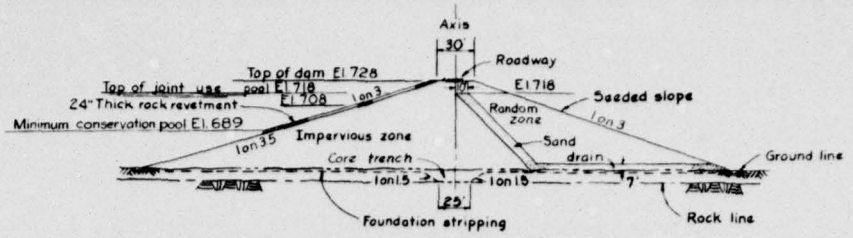


PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONTAL SCALE IN FEET

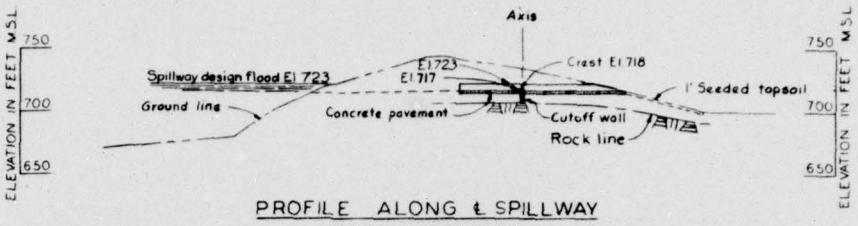
200 0 200 400





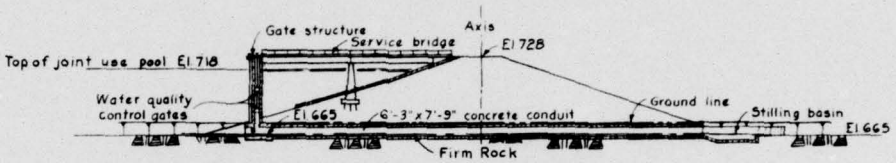
TYPICAL SECTION OF DAM

SCALE IN FEET
50 0 50 100



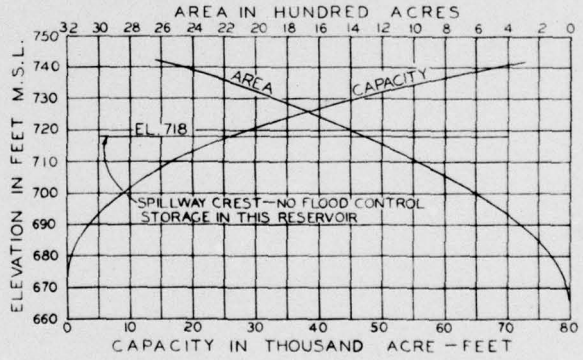
PROFILE ALONG ℄ SPILLWAY

HORIZONTAL SCALE IN FEET
100 0 100 200

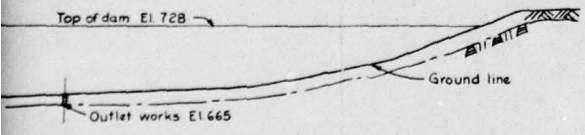


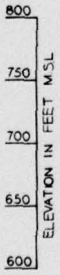
SECTION THRU OUTLET WORKS

SCALE IN FEET
50 0 50 100



RESERVOIR AREA AND CAPACITY CURVES





DOWNSTREAM

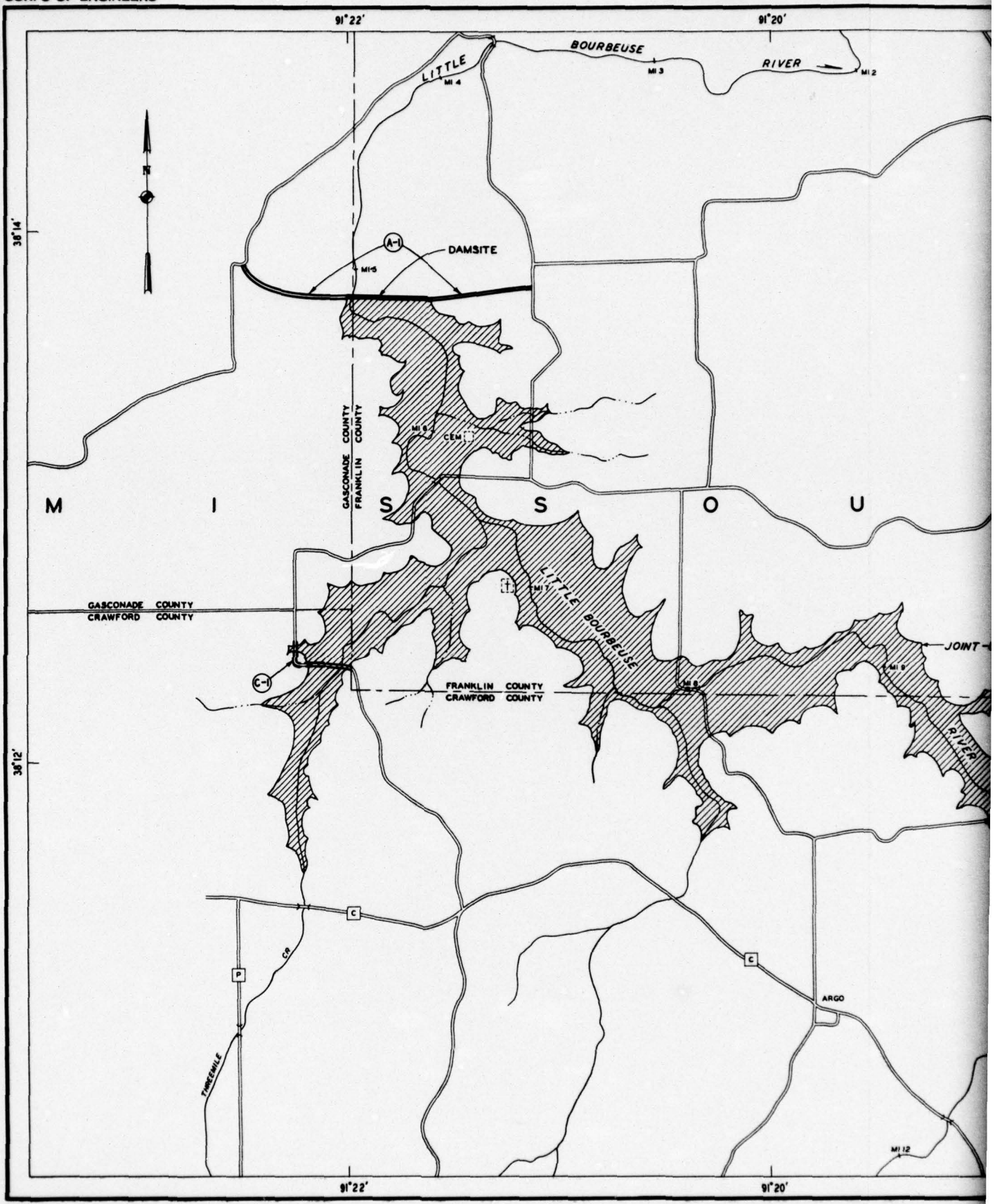
MERAMEC RIVER BASIN, MISSOURI
REDOAK CREEK
DAM I-32
DESIGN DETAILS

IN 1 SHEET — SCALE AS SHOWN — SHEET NO. 1

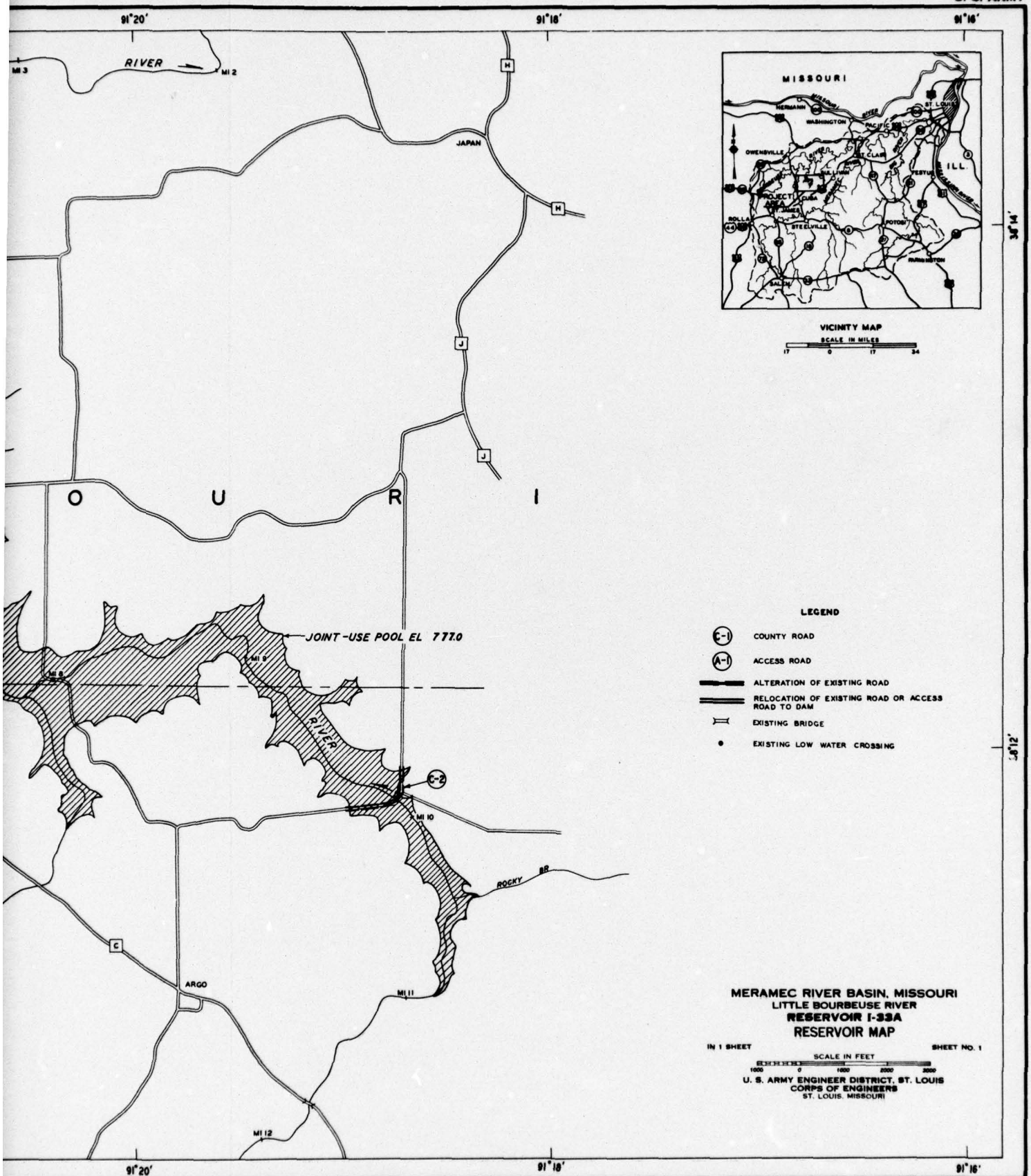
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-33

CORPS OF ENGINEERS



U. S. ARMY



LEGEND

- (C-1) COUNTY ROAD
- (A-1) ACCESS ROAD
- ALTERATION OF EXISTING ROAD
- RELOCATION OF EXISTING ROAD OR ACCESS ROAD TO DAM
- EXISTING BRIDGE
- EXISTING LOW WATER CROSSING

MERAMEC RIVER BASIN, MISSOURI
LITTLE BOURBEUSE RIVER
RESERVOIR I-33A
RESERVOIR MAP

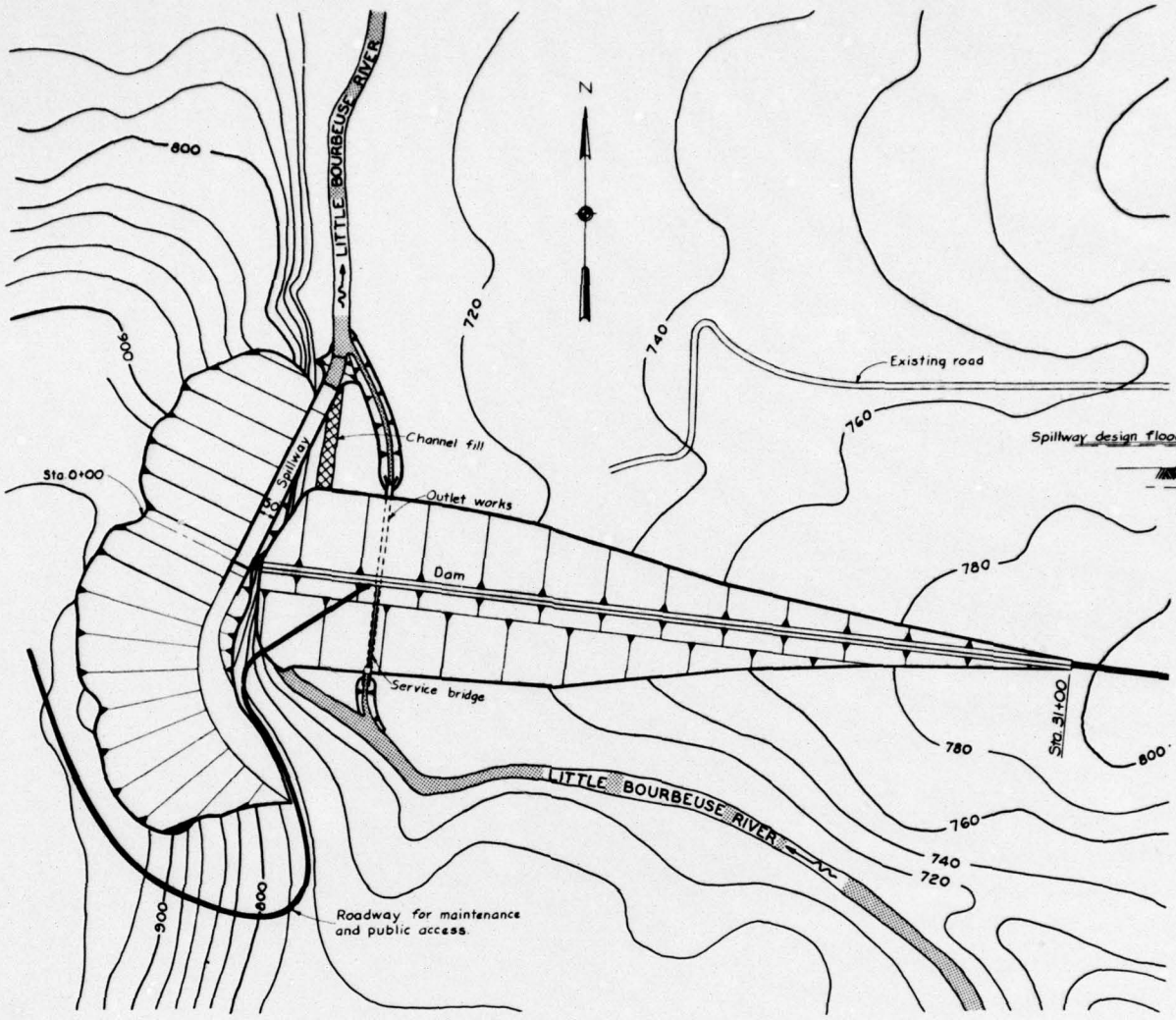
IN 1 SHEET SHEET NO. 1

SCALE IN FEET
1000 0 1000 2000 3000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-34

CORPS OF ENGINEERS

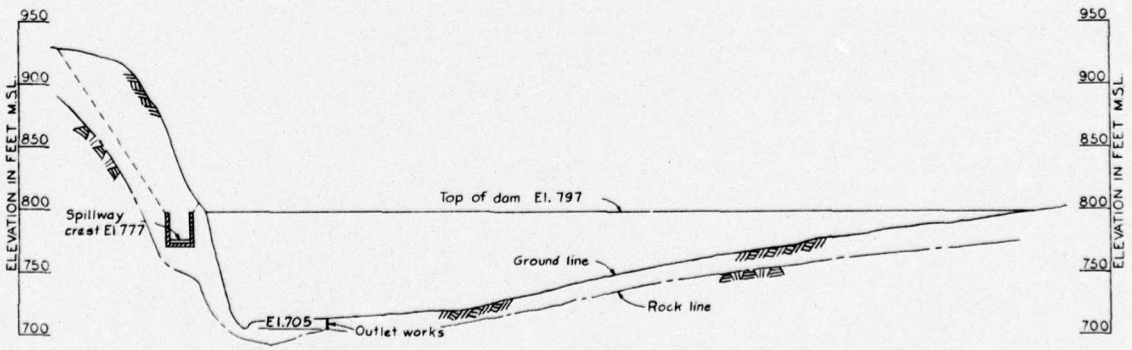


PLAN

SCALE IN FEET

200 0 200 400

CONTOUR INTERVAL 20 FEET

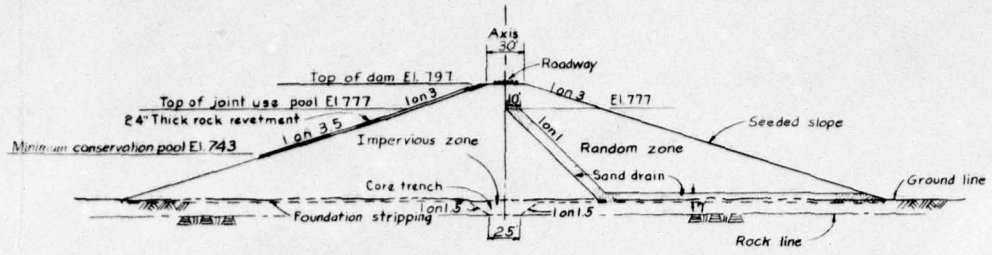


PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONTAL SCALE IN FEET

200 0 200 400

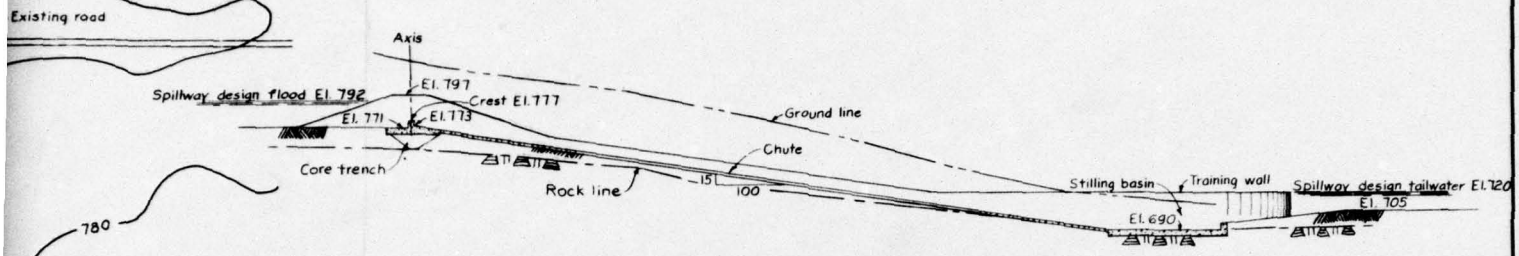
20



TYPICAL SECTION OF DAM

SCALE IN FEET

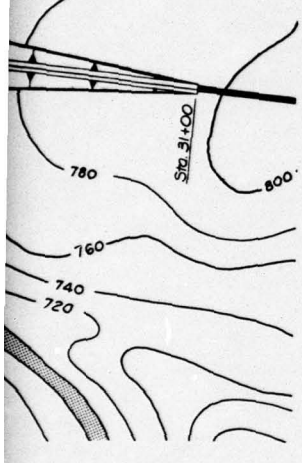
50 0 50 100

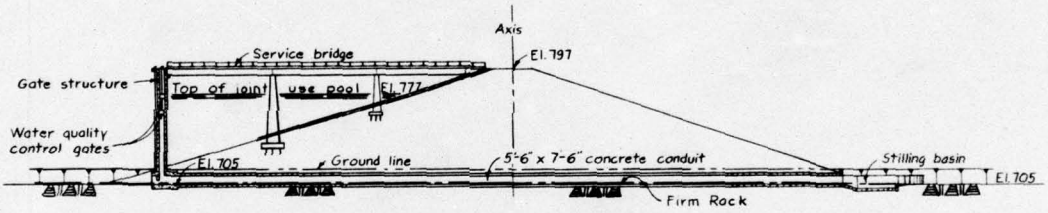


PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET

50 0 50 100

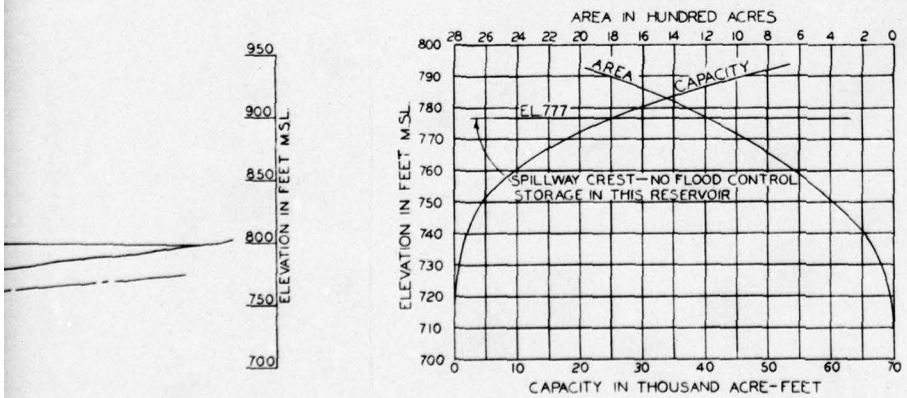




SECTION THRU OUTLET WORKS

SCALE IN FEET

50 0 50 100



RESERVOIR AREA AND CAPACITY CURVES

MERAMEC RIVER BASIN, MISSOURI
LITTLE BOURBEUSE RIVER
DAM 1-33A
DESIGN DETAILS

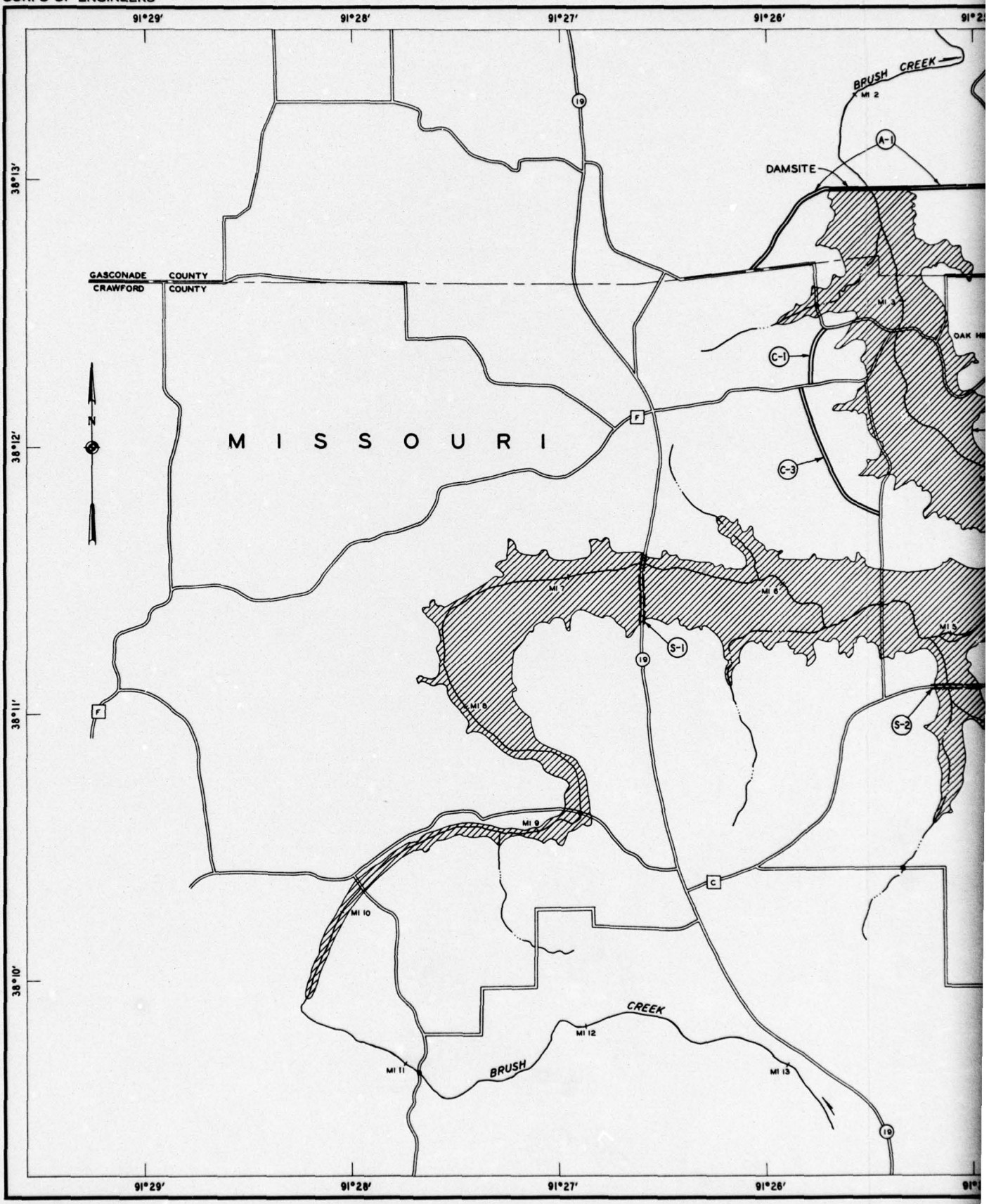
IN 1 SHEET SHEET NO. 1

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-35

CORPS OF ENGINEERS



U. S. ARMY

2

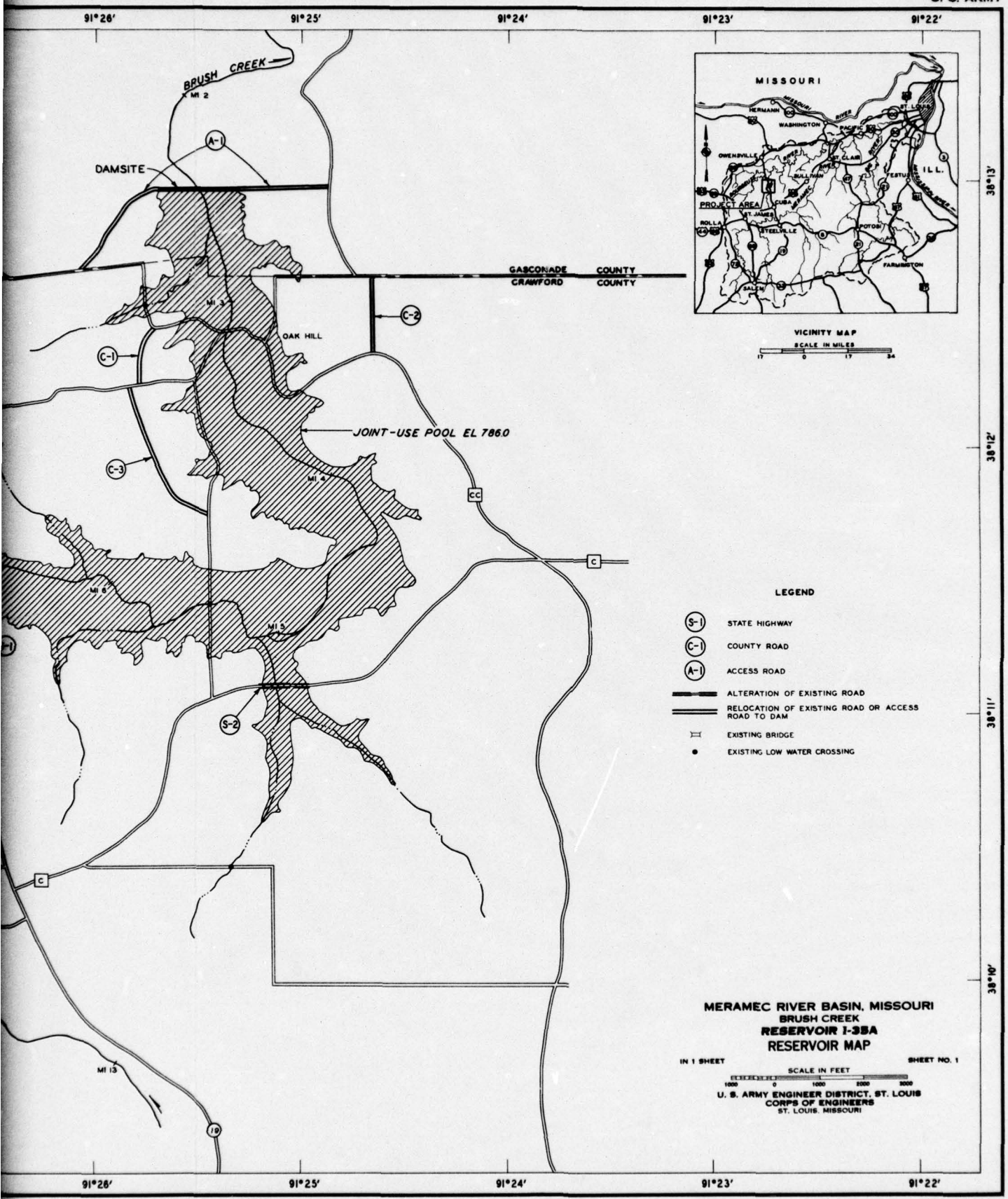
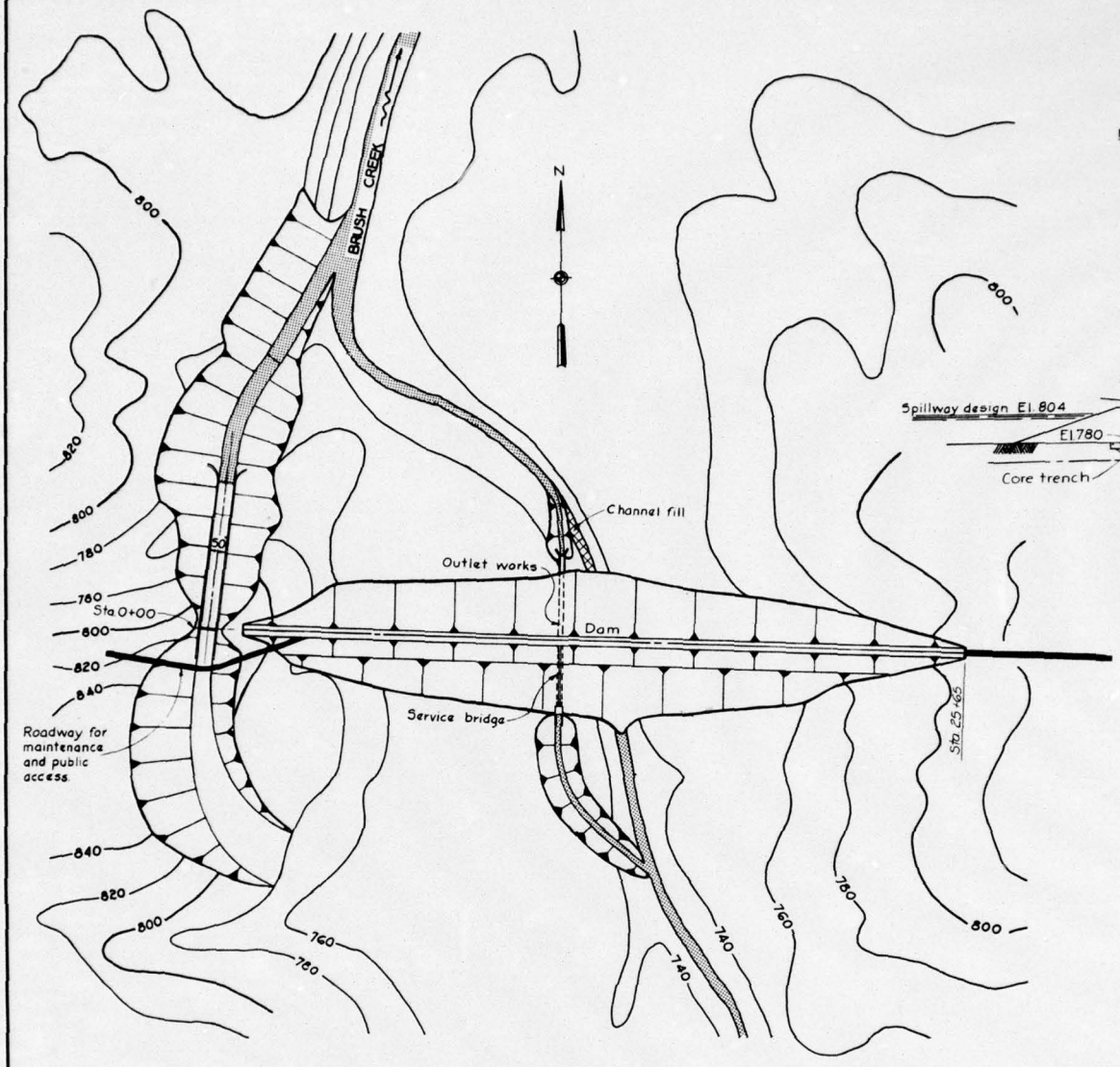


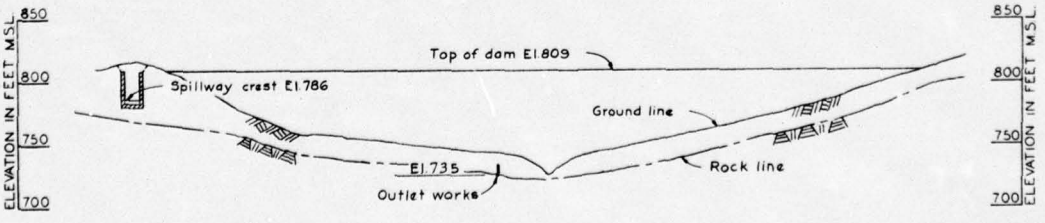
PLATE E-36

CORPS OF ENGINEERS



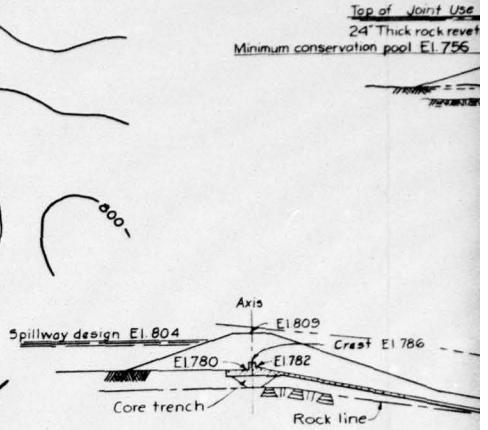
PLAN

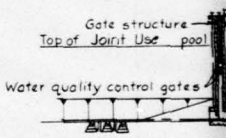
SCALE IN FEET
200 0 200 400
CONTOUR INTERVAL 20 FEET

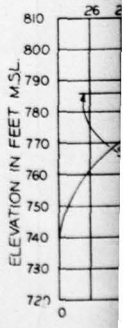


PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONTAL SCALE IN FEET
200 0 200 400



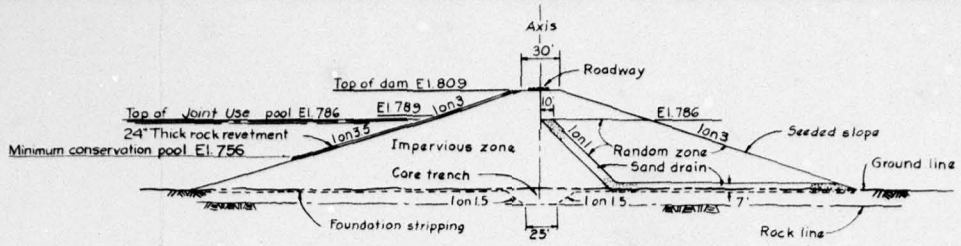




RESERV

U. S. ARMY

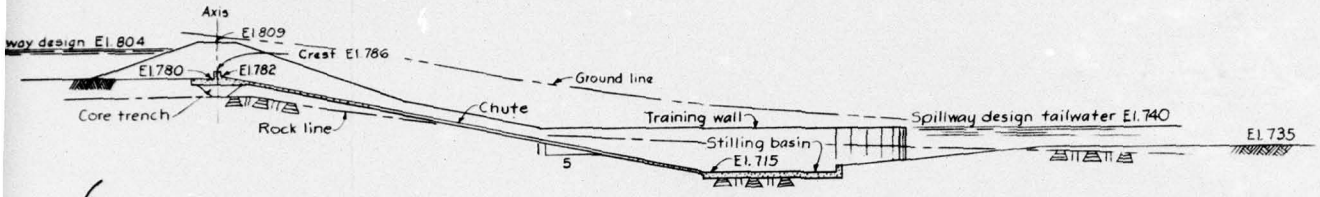
2



TYPICAL SECTION OF DAM

SCALE IN FEET

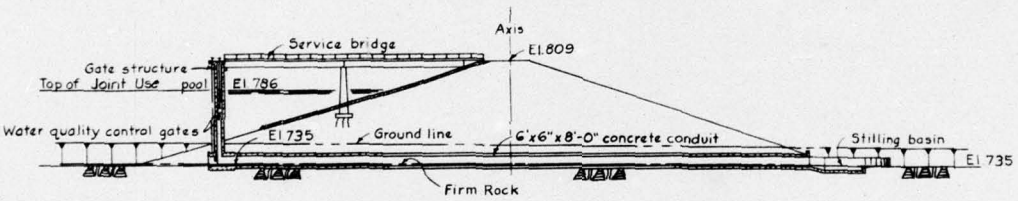
50 0 50 100



PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET

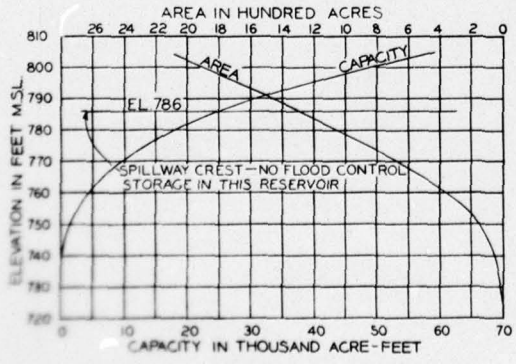
50 0 50 100



SECTION THRU OUTLET WORKS

SCALE IN FEET

50 0 50 100



RESERVOIR AREA AND CAPACITY CURVES

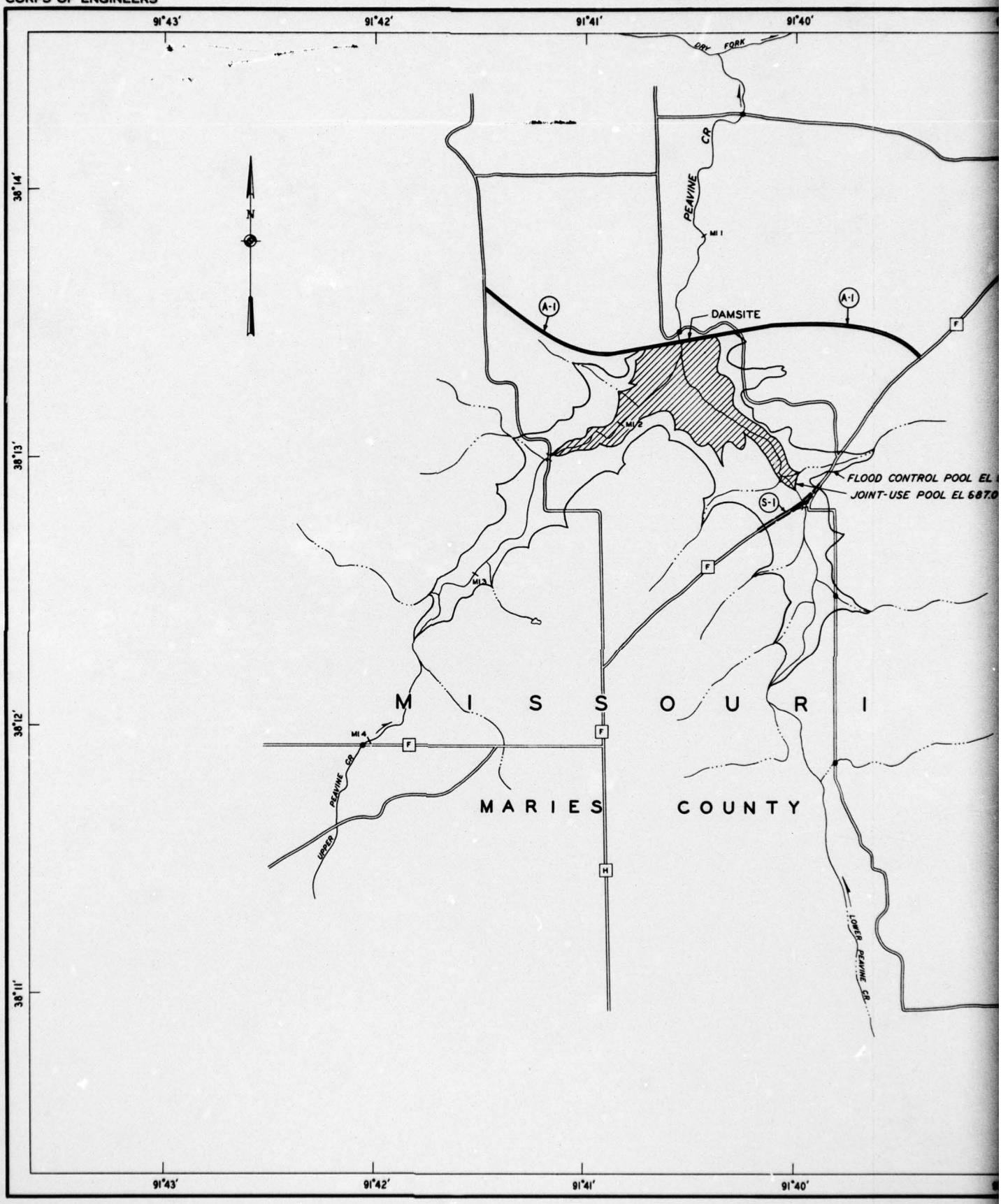
MERAMEC RIVER BASIN, MISSOURI
BRUSH CREEK
DAM I-35A
DESIGN DETAILS

IN 1 SHEET — SCALE AS SHOWN — SHEET NO. 1

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-37

CORPS OF ENGINEERS



U. S. ARMY

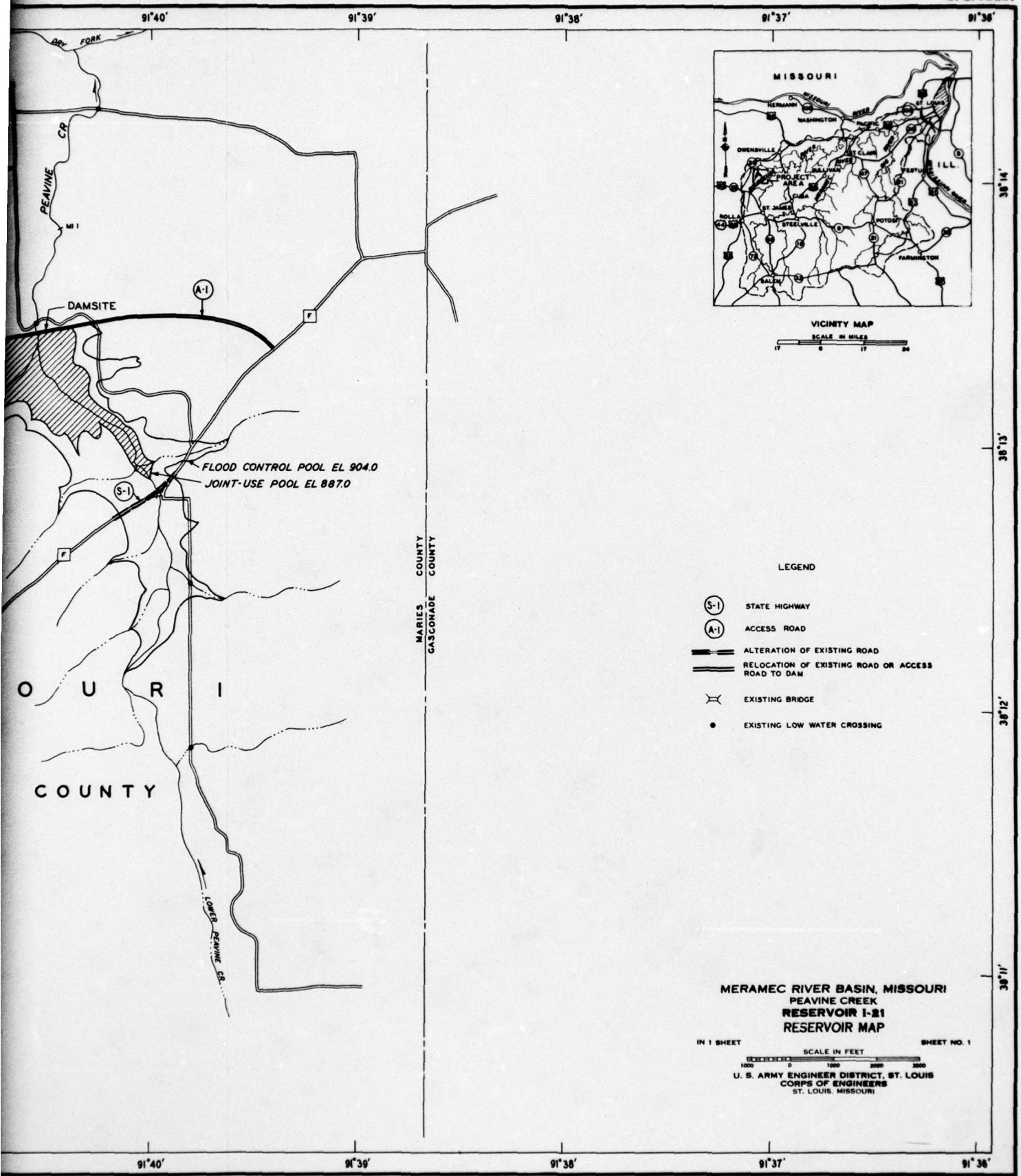
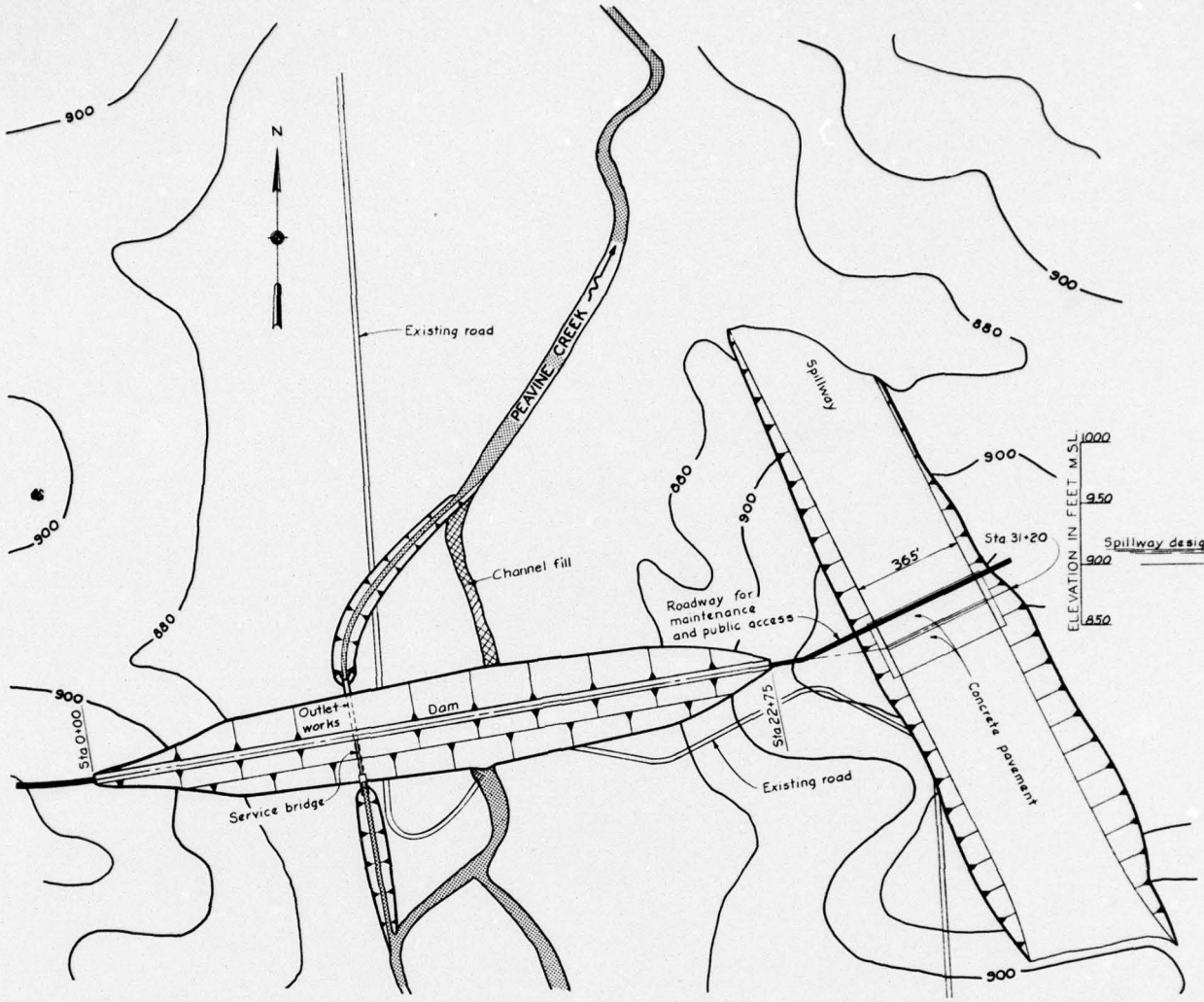


PLATE E-38

CORPS OF ENGINEERS

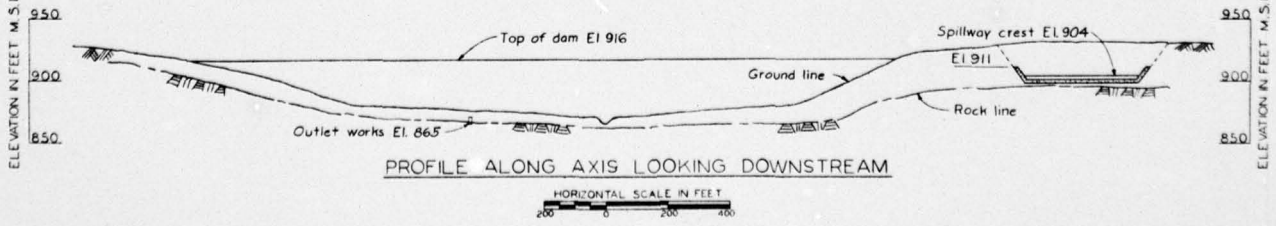


PLAN

SCALE IN FEET

200 0 200 400

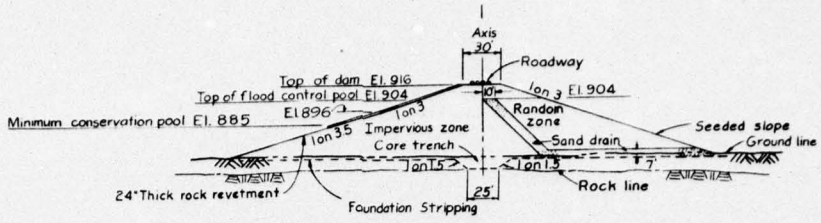
CONTOUR INTERVAL 20 FEET



PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONTAL SCALE IN FEET

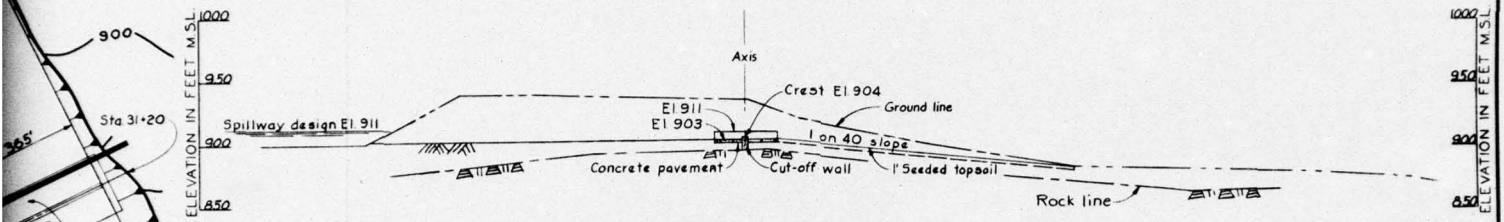
200 0 200 400



TYPICAL SECTION OF DAM

SCALE IN FEET

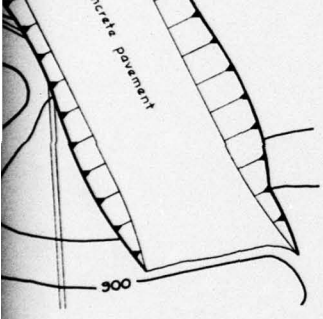
50 0 50 100

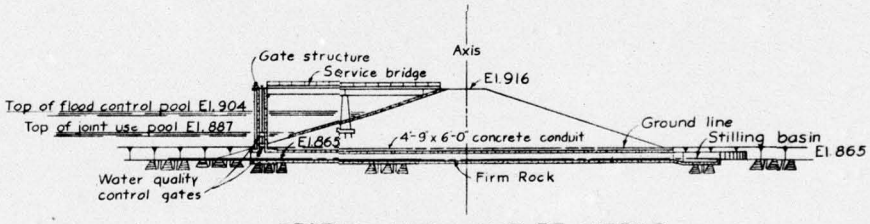


PROFILE ALONG ℄ SPILLWAY

HORIZONTAL SCALE IN FEET

200 0 200 400

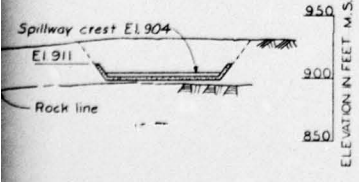


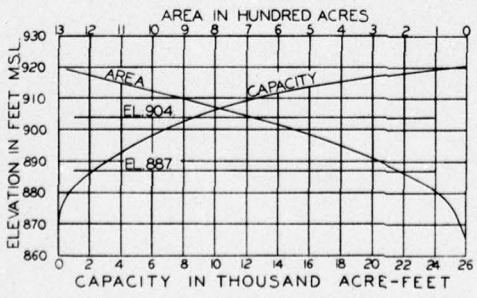


SECTION THRU OUTLET WORKS

SCALE IN FEET

50 0 50 100





RESERVOIR AREA AND CAPACITY CURVES

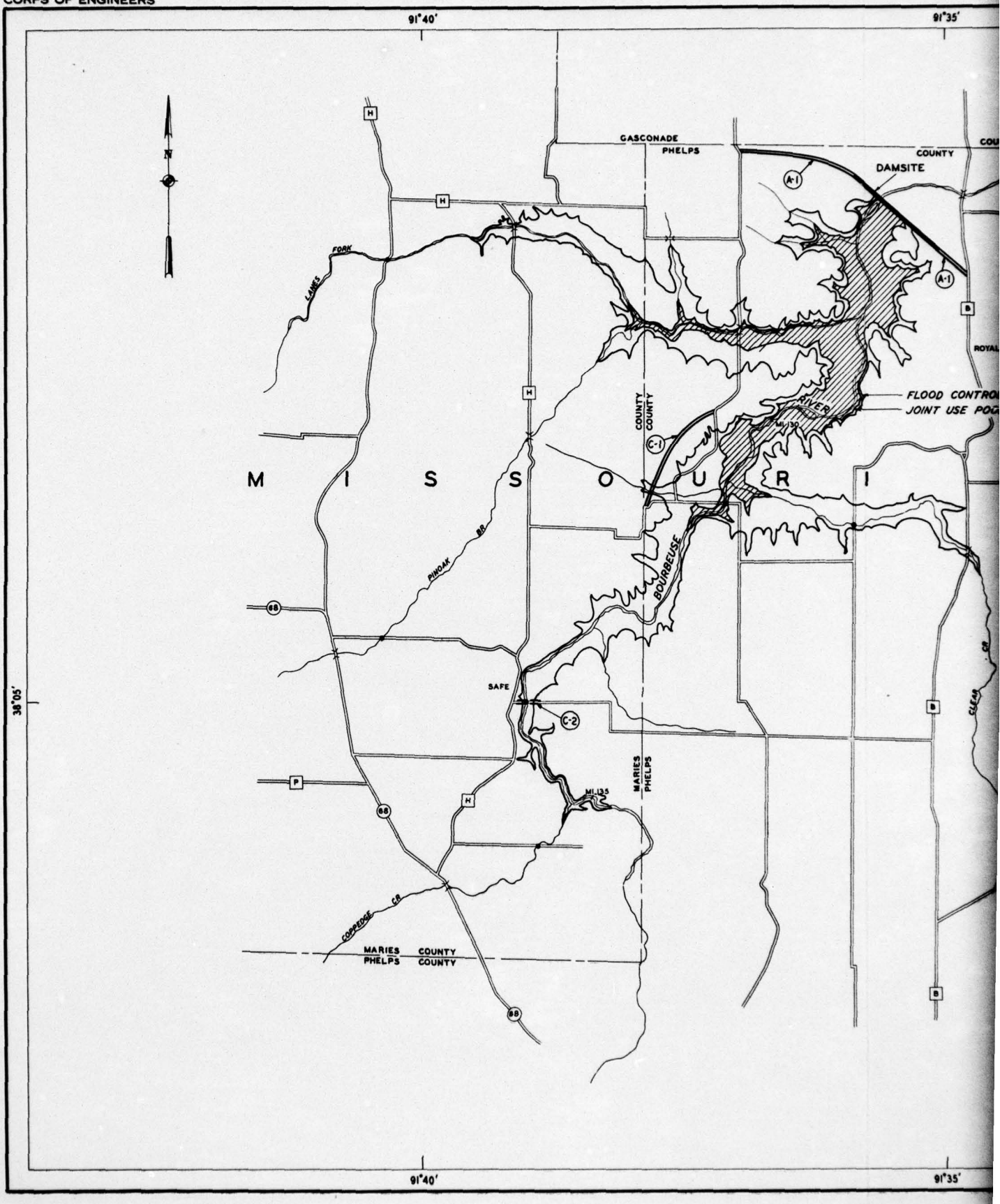
MERAMEC RIVER BASIN, MISSOURI
PEAVINE CREEK
DAM I-21
DESIGN DETAILS

IN 1 SHEET SCALE AS SHOWN SHEET NO. 1

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-39

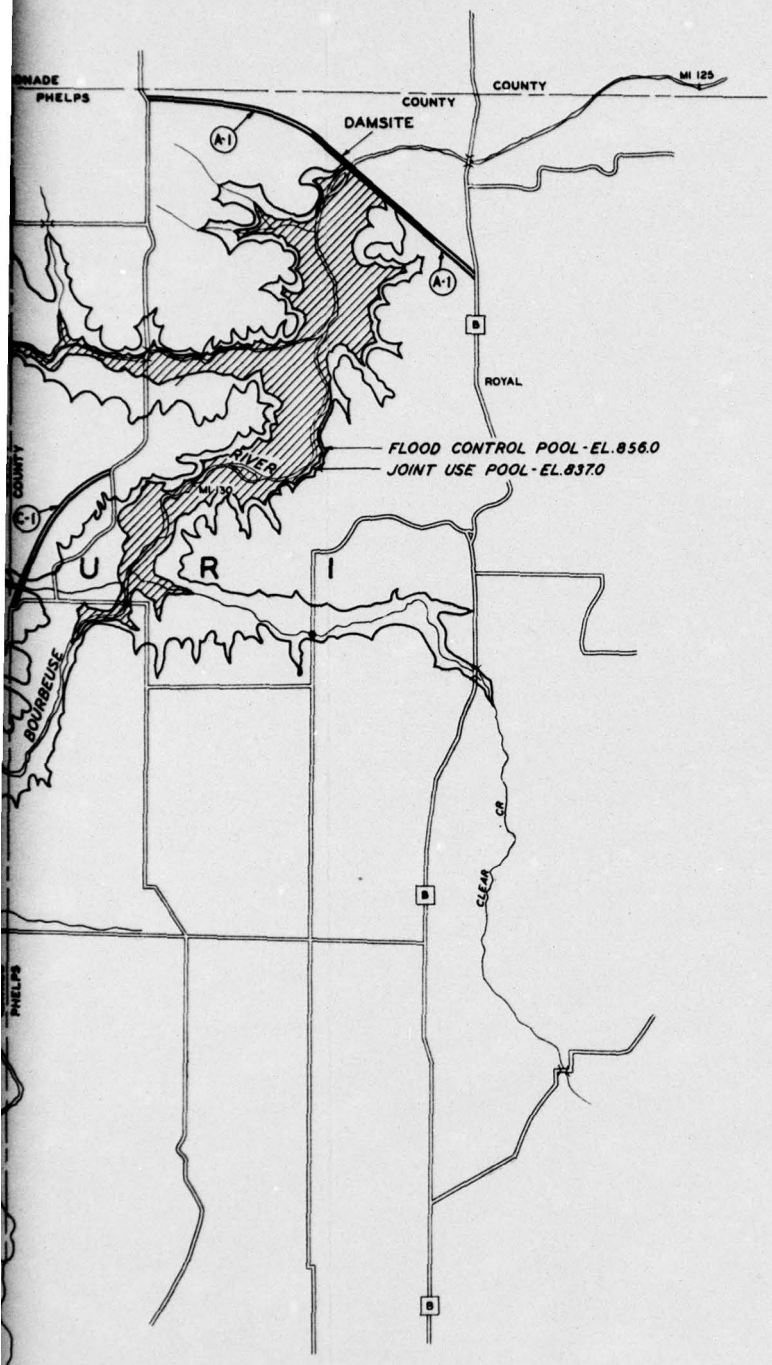
CORPS OF ENGINEERS



U. S. ARMY

91°35'

91°30'



VICINITY MAP

SCALE IN MILES

17 0 17 34

38°05'

LEGEND

- (A-1) ACCESS ROAD
- (C-1) COUNTY ROAD
- ALTERATION OF EXISTING ROAD
- RELOCATION OF EXISTING ROAD OR ACCESS ROAD TO DAM
- EXISTING BRIDGE
- EXISTING LOW WATER CROSSING

MERAMEC RIVER BASIN, MISSOURI
BOURBEUSE RIVER
RESERVOIR I-38
RESERVOIR MAP

IN 1 SHEET SHEET NO. 1

SCALE IN FEET

2000 0 2000 4000 6000

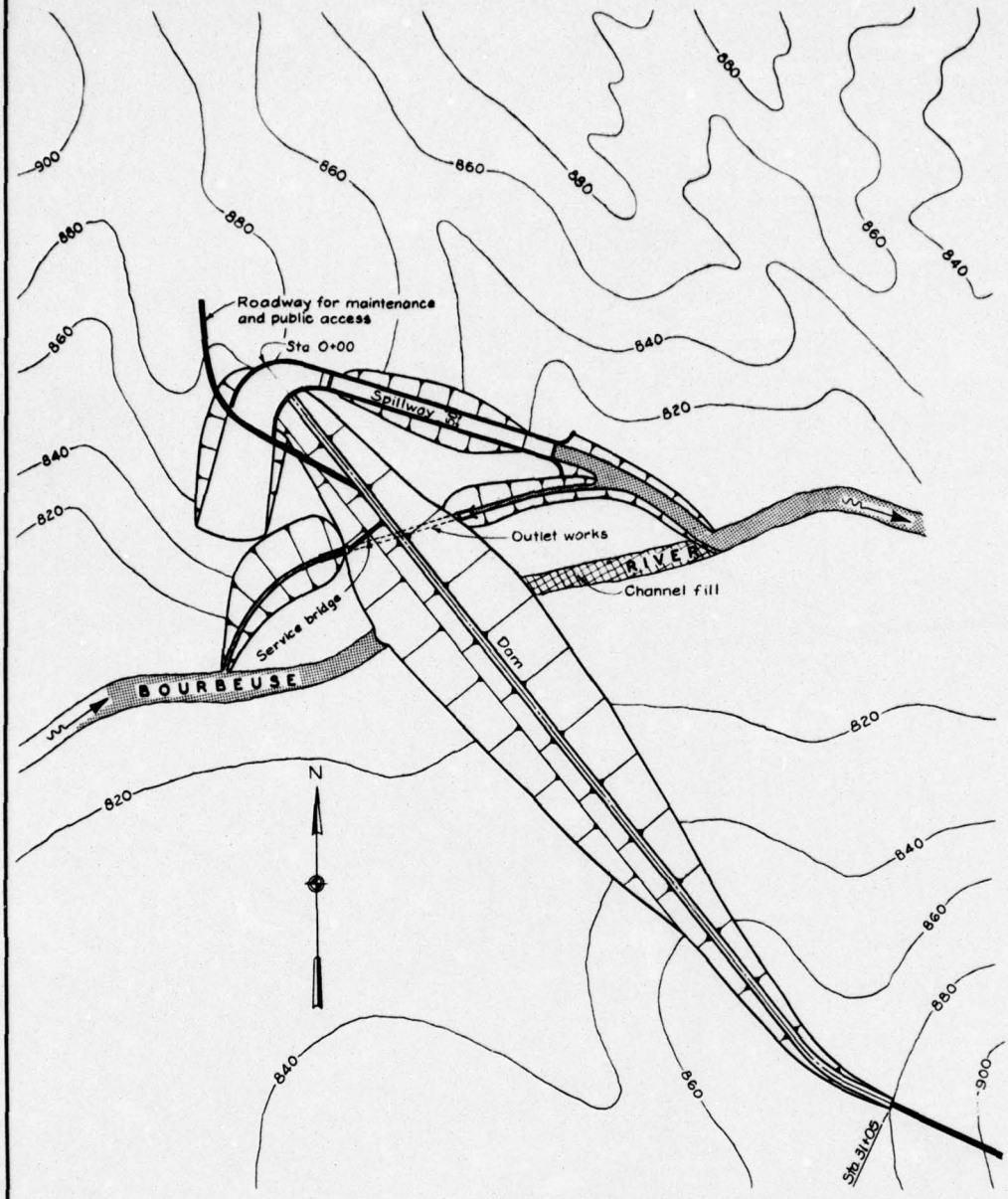
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

91°35'

91°30'

PLATE E-40

CORPS OF ENGINEERS

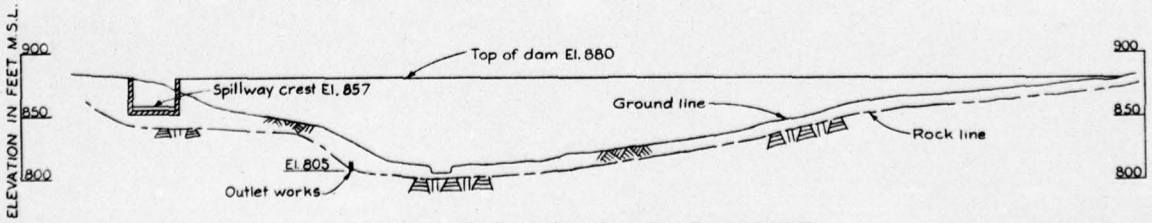


PLAN

SCALE IN FEET

200 0 200 400

CONTOUR INTERVAL 20 FEET



PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONTAL SCALE IN FEET

200 0 200 400

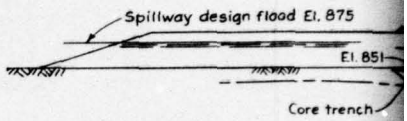
Top of flood

24" Thick

Minimum conservation pool

Impervious

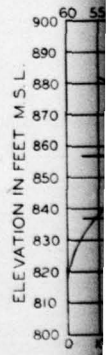
Fou



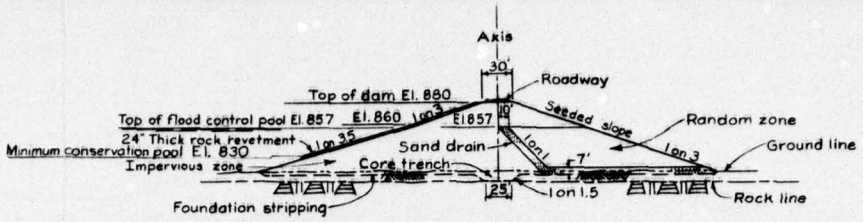
Top of flood control p

Top of joint us

Water quality c

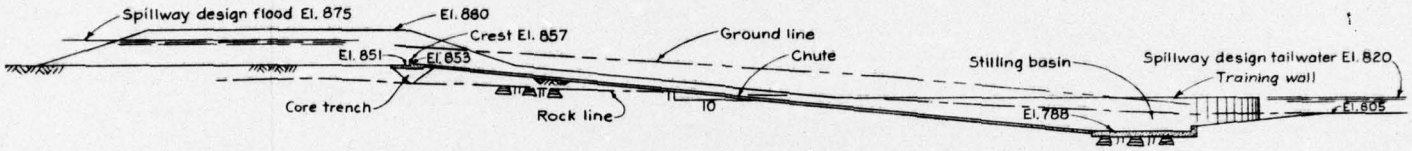


RESERV



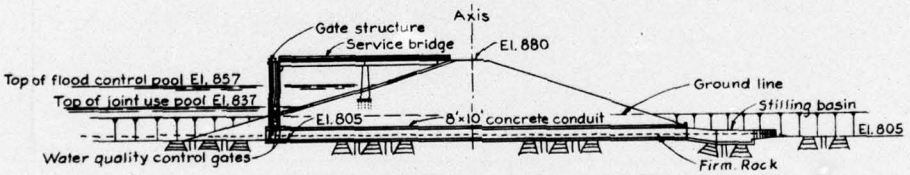
TYPICAL SECTION OF DAM

SCALE IN FEET
60 0 60 120



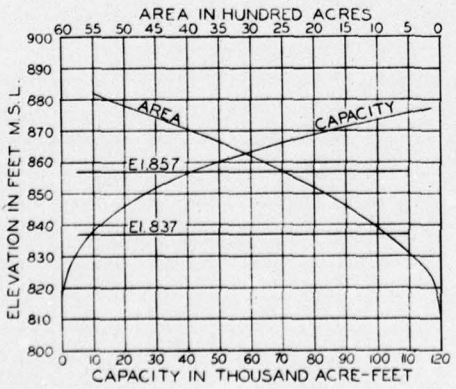
PROFILE ALONG ℄ SPILLWAY

SCALE IN FEET
60 0 60 120



SECTION THRU OUTLET WORKS

SCALE IN FEET
60 0 60 120



RESERVOIR AREA AND CAPACITY CURVES

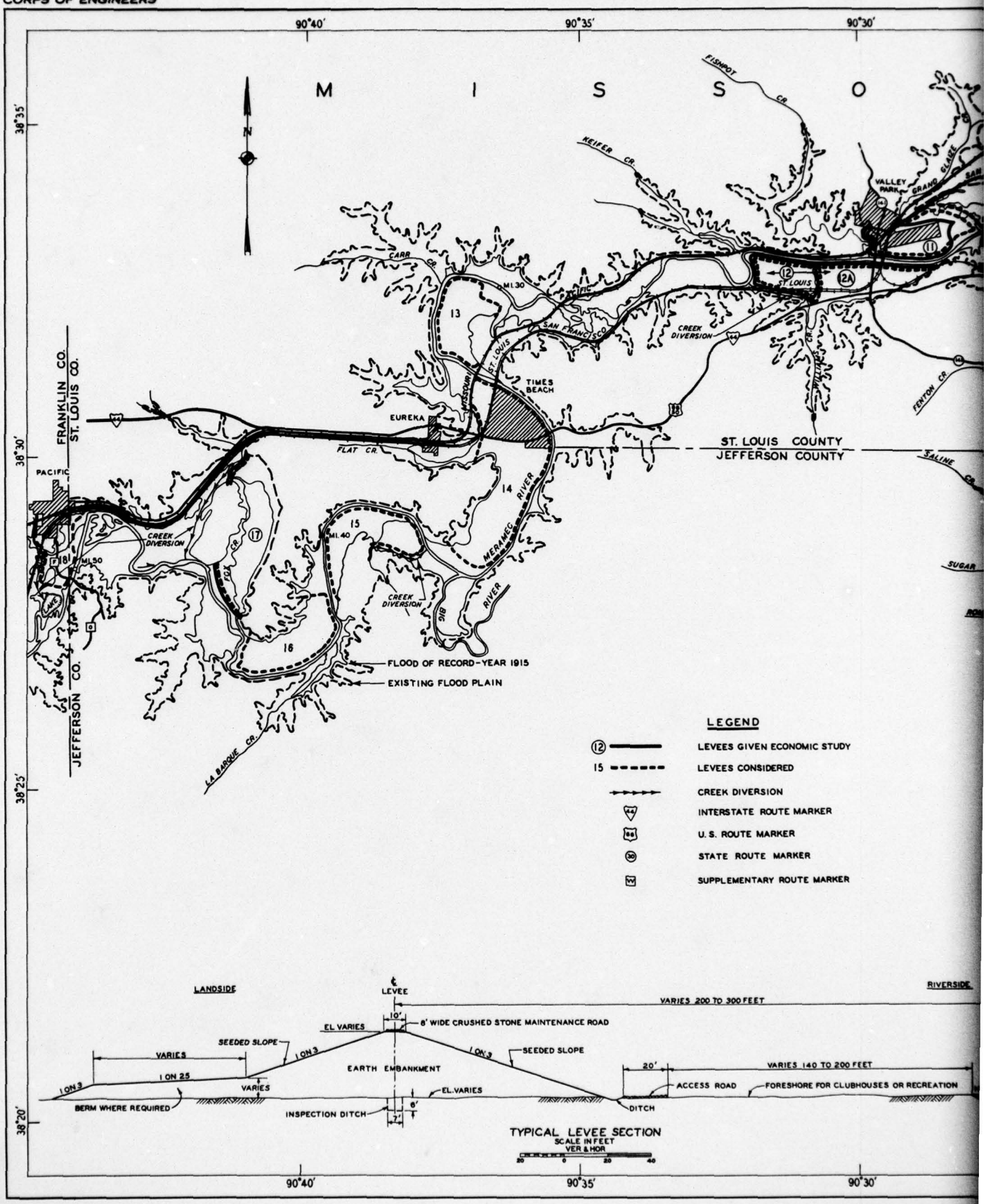
MERAMEC RIVER BASIN, MISSOURI
BOURBEUSE RIVER
DAM 1-38
DESIGN DETAILS

IN 1 SHEET SHEET NO. 1
SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

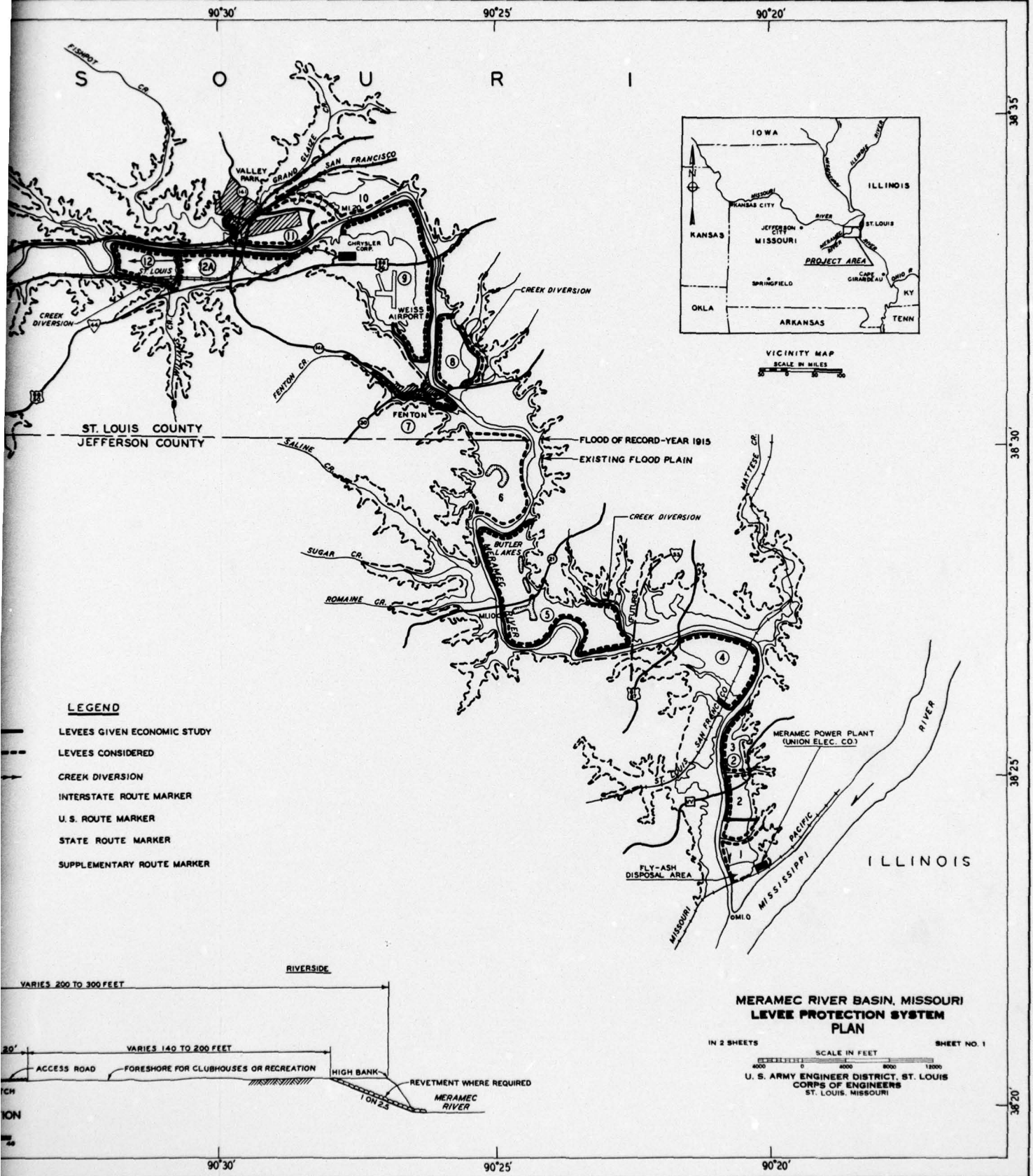
PLATE E-41

CORPS OF ENGINEERS



U. S. ARMY

2



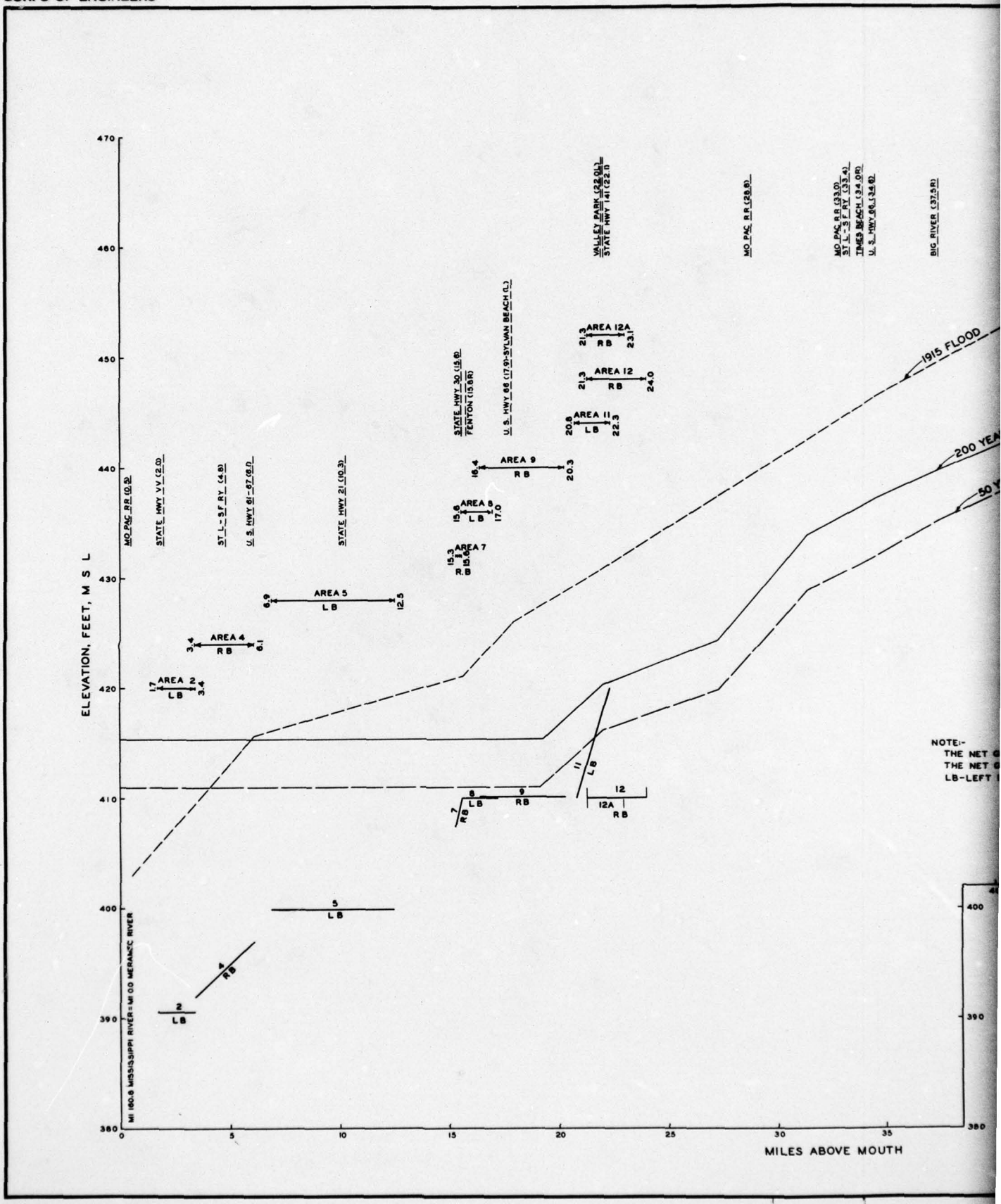
MERAMEC RIVER BASIN, MISSOURI
LEVEE PROTECTION SYSTEM
PLAN

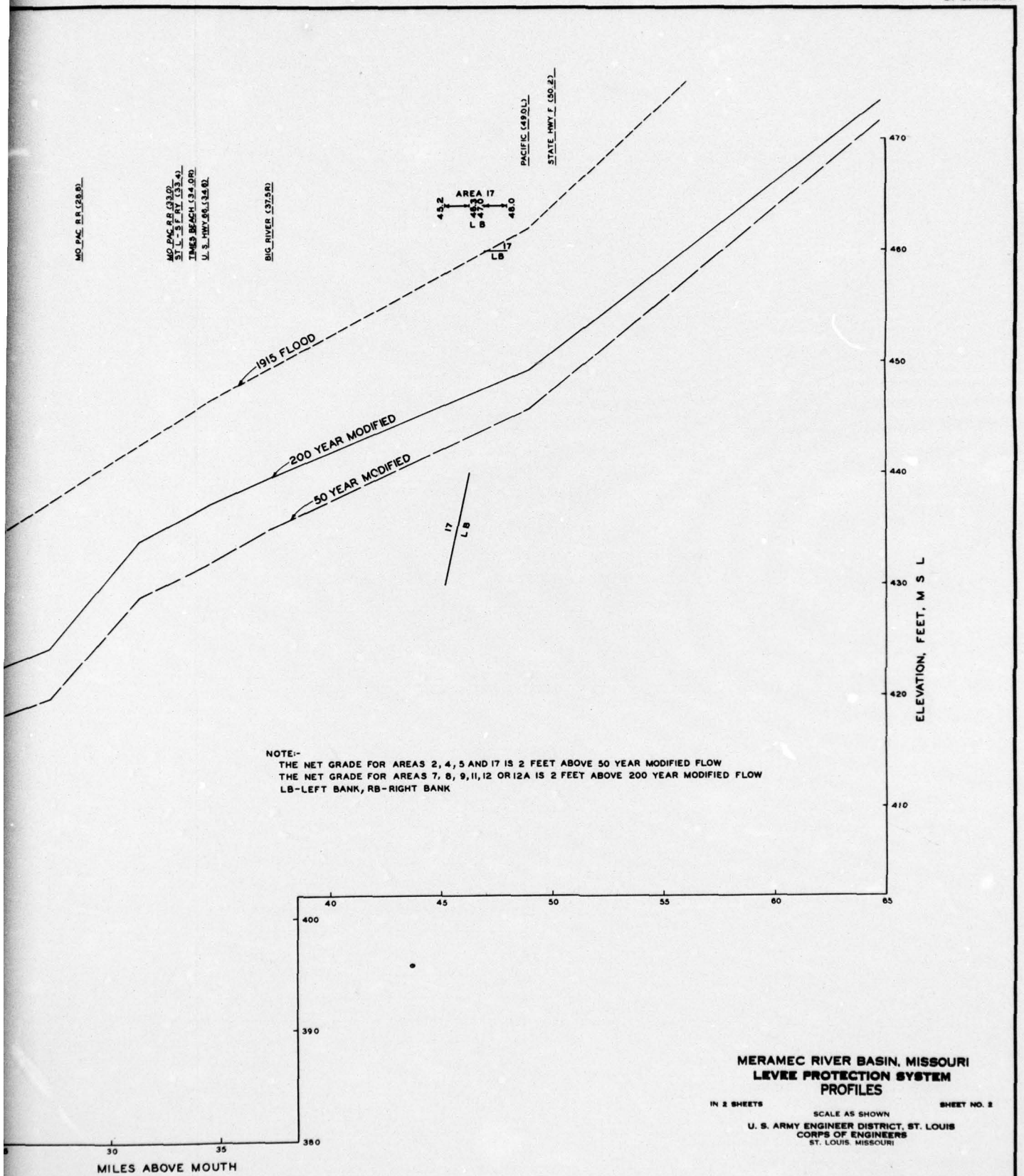
IN 2 SHEETS — SHEET NO. 1

SCALE IN FEET

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-42


ELEVATION, FEET, M S L
MILES ABOVE MOUTH
MI 180.6 MISSISSIPPI RIVER=MI 0.0 MERAMEC RIVER
MO PAC R.R (0.2)
STATE HWY VV (2.0)
ST L-S F RY (4.8)
U S HWY 61-67 (6.7)
STATE HWY 21 (10.3)
STATE HWY 30 (15.8) FENTON (15.8R)
U S HWY 66 (17.0)-SYLVAN BEACH (L)
VALLEY PARK (22.0L) STATE HWY 141 (22.1)
MO PAC R.R (28.8)
MO PAC R.R (33.0)
ST L-S F RY (33.4)
TIMES BEACH (34.0R)
U S HWY 66 (34.6)
BIG RIVER (37.5R)
1915 FLOOD
200 YEA
50 Y
AREA 2 LB 1.7 3.4
AREA 4 RB 3.4 6.1
AREA 5 LB 6.9 12.5
AREA 7 R.B 15.3 15.6
AREA 8 LB 15.8 17.0
AREA 9 RB 16.4 20.3
AREA 11 LB 20.8 22.3
AREA 12 RB 21.3 24.0
AREA 12A RB 21.3 23.1
2 LB
4 RB
5 LB
7 RB
8 LB
9 RB
11 LB
12 RB
12A RB
NOTE:-
THE NET G
THE NET G
LB-LEFT
470
460
450
440
430
420
410
400
390
380
0
5
10
15
20
25
30
35



NOTE:-
THE NET GRADE FOR AREAS 2, 4, 5 AND 17 IS 2 FEET ABOVE 50 YEAR MODIFIED FLOW
THE NET GRADE FOR AREAS 7, 8, 9, 11, 12 OR 12A IS 2 FEET ABOVE 200 YEAR MODIFIED FLOW
LB-LEFT BANK, RB-RIGHT BANK

MERAMEC RIVER BASIN, MISSOURI
LEVEE PROTECTION SYSTEM
PROFILES

IN 2 SHEETS SHEET NO. 2

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE E-43

COMPREHENSIVE REPORT

MERAMEC RIVER BASIN, MISSOURI

APPENDIX F

HYDROPOWER

AD-A041 696 ARMY ENGINEER DISTRICT ST LOUIS MO F/G 13/2
MERAMEC RIVER, MISSOURI COMPREHENSIVE BASIN STUDY. VOLUME V. AP--ETC(U)
JAN 64

UNCLASSIFIED NL

3 OF 3
AD
A041696

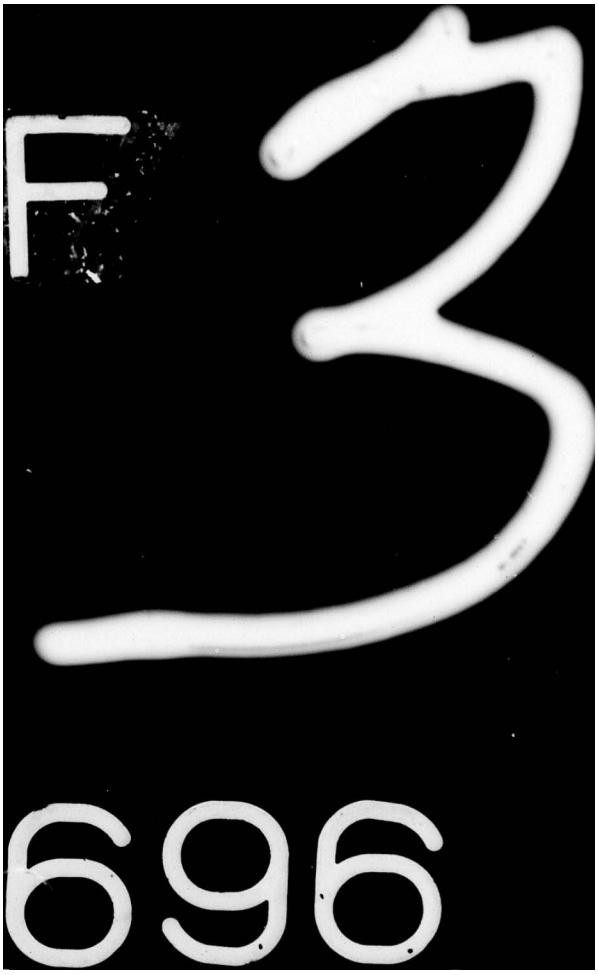

F
3
696

TABLE OF CONTENTS

Paragraph	Subject	Page
	SECTION I - PERTINENT INFORMATION	
1.	INTRODUCTION	F-1
2.	COORDINATION	F-1
	a. Federal Power Commission	F-1
	b. Southwestern Power Administration	F-1
3.	CONVENTIONAL POWER	F-2
4.	PUMPED STORAGE	F-2
	a. On-site	F-3
	b. Adjoining	F-3
5.	COMBINED PUMPED STORAGE AND CONVENTIONAL PLANT	F-4
	SECTION II - DESIGN DATA - MERAMEC PARK	
6.	HEAD AND DISCHARGE DATA	F-5
7.	DESIGN DETAILS	F-6
	a. Plan I	F-6
	b. Plan II	F-6
	c. Plan III	F-7
8.	FOUNDATION INVESTIGATIONS	F-8
	a. Methods and results	F-8
	b. Remedial measures	F-9
	SECTION III - DESIGN DATA - PINE FORD	
9.	HEAD AND DISCHARGE DATA	F-10
10.	DESIGN DETAILS	F-11
	a. Plan I	F-11
	b. Plan II	F-11
	c. Maximum power plan	F-11
11.	FOUNDATION INVESTIGATIONS	F-12
	SECTION IV - DESIGN DATA - SALEM	
12.	HEAD AND DISCHARGE DATA	F-13
13.	DESIGN DETAILS	F-14
	a. Plan I	F-14
	b. Plan II	F-14
	c. Maximum power plan	F-14
14.	FOUNDATION INVESTIGATIONS	F-15

Paragraph	Subject	Page
	SECTION V - COST ESTIMATES	
15.	SUMMARY OF COST	F-16
	a. Meramec Park	F-16
	b. Pine Ford	F-17
	c. Salem	F-17
	SECTION VI - ECONOMIC ANALYSIS	
16.	SUMMARY	F-62
17.	JUSTIFICATION	F-62
18.	SUPPLEMENTARY DATA	F-63
	a. Federal Power Commission study	F-63
	b. Corps of Engineers review	F-63

TABLES

Table No.	Title	Page
F-1	Potential conventional hydropower capabilities of Meramec damsites	F-2
F-2	Head and discharge data for pumped-storage plans studied	F-3
F-3	Pertinent design data - Meramec Park Reservoir	F-5
F-4	Pertinent design data - Pine Ford Reservoir	F-10
F-5	Pertinent design data - Salem Reservoir	F-13
F-6	Cost summary - power plans investigated	F-16
F-7	Detailed cost estimates for power plans investigated	F-19
F-8	Comparative cost per kilowatt	F-62

EXHIBITS

Exhibit No.	
F-1	Southwestern Power Administration letter dated 18 October 1963
F-2	Federal Power Commission letter dated 1 November 1963

PLATES

Plate No.	Title
F-1	Meramec Park Hilltop Dam - Hydroelectric Power Features
F-2	Meramec Park Hilltop Dam - Power Facilities
F-3	Pine Ford Hilltop Dam - Hydroelectric Power Features
F-4	Salem Hilltop Dam - Hydroelectric Power Features

SUPPLEMENT

By Federal Power Commission, Chicago Regional Office

COMPREHENSIVE REPORT
MERAMEC RIVER BASIN, MISSOURI

APPENDIX F

HYDROPOWER

SECTION I - PERTINENT INFORMATION

1. INTRODUCTION

Development of hydroelectric power was included as a purpose to be considered in formulating the plan of development of water resources in the Meramec River Basin. This appendix presents design details, cost estimates, economic analyses, and discussion of plans investigated.

2. COORDINATION

a. Federal Power Commission. The Federal Power Commission participated in the basin investigation by making load duration curve studies of fitting various power installations onto future Meramec Basin market area loads. Its report is included in the attached SUPPLEMENT. It has also furnished the following at-site capacity and energy values based on both Federal and private financing of alternative steam-electric plants.

	Federal	Private
Capacity value	$10 per KW per year	$23
Energy	1.9 mills per KWH	1.9
Taxes included		$ 8.50
Cost of energy for pumping	2.0 mills per KWH	2.0

b. Southwestern Power Administration. The Southwestern Power Administration furnished data on the potential hydroelectric power demand of the area and has indicated that both conventional and pumped storage should be considered. Furthermore, the Southwestern Power Administration has indicated that there will be a market available for the power generated in the basin by 1980, provided that it can be generated at a suitable cost and load factor. The Southwestern Power Administration determines power rates and repayment schedules. It has stated that experience in the marketing of conventional power indicates that, as a minimum, generation at an average annual load factor of 10 percent and a higher factor during peak load months could be marketed. A daily load factor of at least 25 percent would be necessary to meet marketing requirements for power from pumped storage.

3. CONVENTIONAL POWER

The seven major sites selected for consideration were investigated to determine if there were stream flow possibilities sufficient for consideration of conventional power. The following table presents flow and head data.

TABLE F-1

Potential conventional hydropower capabilities of Meramec damsites

Reservoir	Mean stream flow (c.f.s.)	Minimum stream flow (c.f.s.)	Joint-use storage assigned (ac.-ft.)	Normal pool elev.	Tail-water elev.	Avail. head (losses -3 ft.)	Regulated discharge (c.f.s.)	Installed capacity (KW)
			Meramec Basin					
Meramec Park (17)	1,237	134	400,200	667	564	100	3,500	24,000
Salem (27)	131	17	50,200	973	900	70	680	3,300
Virginia Mines (40)	1,433	155	101,300	556	509	44	5,010	15,600
			Bourbeuse Basin					
Union (29)	611	11	160,500	616	537	76	2,140	11,400
			Big River Basin					
Washington Park (5)	155	6	43,500	666	593	70	670	3,300
Irondale (9)	170	7	49,000	832	764	65	730	3,300
Pine Ford (2A)	749	30	76,300	561	505	53	3,150	11,700

Analysis of the above data indicated that, except for Meramec Park which could justify installation of 24,000 KW at 10 percent load factor, none of the other six sites had sufficient head or assured discharge to justify the installation of more than 5,000 KW at a 10 percent load factor. The Federal Power Commission concurred in these findings.

4. PUMPED STORAGE

Consideration has also been given to pumped-storage developments. Two such types of developments were considered:

a. On-site, where reservoir discharges for peaking power are passed through reversible pump-turbine units to a tailwater impoundment below the dam and pumped back to the reservoir during off-peak periods.

b. Adjoining, where the topography is such that a higher adjacent impoundment is feasible. In this type of development, water is pumped from the main reservoir to a higher auxiliary reservoir, and power is generated by the reversible pump-turbine units when the water is returned to the main reservoir.

A limiting factor on the quantity of water that can be recirculated to and from the main reservoir is the maximum daily fluctuation of the main reservoir pool that can be tolerated without adversely affecting recreational use. After consultation with recreational agencies, this was determined to be 2 feet. The Southwestern Power Administration has stated that pumped-storage installations should provide 6 hours' daily energy or 25 percent load factor generation during the week. There are only three reservoir sites where the topography is such that adjoining developments for pumped storage are possible. These are Meramec Park, Pine Ford, and Salem. Head and discharge data on both types of developments are summarized below.

TABLE F-2
Head and discharge data for pumped-storage plans studied

	Meramec Park		Pine Ford		Salem	
	On-site	Adjoining	On-site	Adjoining	On-site	Adjoining
Average net head (ft.)	90	140	48	155	88	139
Daily drawdown (ac.-ft.)	6,000	6,000	7,000	7,000	5,000	5,000
Load factor	25%	25%	25%	25%	25%	25%

It is obvious from the above table that a much greater head and consequently a greater capacity are available from the adjoining impoundment than from the on-site development. Furthermore, in order to provide the required downstream storage, considerable excavation of the stream channel, up to depths of 30 feet at the main dam and extending several miles downstream, would be required for each of the proposed sites. Because of this condition and the resulting high cost of construction, downstream dams for pumped storage were not given further consideration.

5. COMBINED PUMPED STORAGE AND CONVENTIONAL PLANT

At Meramec Park, the adjoining development plan could be used in conjunction with a conventional plant located 1.3 miles downstream of the dam. Advantage could be taken of the 140-foot additional head by pumping an additional 700 acre-feet of water from the Meramec Park Reservoir to the higher impoundment. In this alternate plan, discharge would be released through penstocks tunneled from the higher impoundment to a conventional plant at the river. The following power plans were investigated.

Meramec Park

Plan I - Conventional power - 10 percent load factor
Plan II - Pumped power - 25 percent load factor
Plan III - Combined pumped storage and conventional plant - 10 percent load factor

Pine Ford

Pumped power - 25 percent load factor

Salem

Pumped power - 25 percent load factor

6. HEAD AND DISCHARGE DATA

TABLE F-3 presents pertinent data for the alternate power plans investigated, which are further discussed in subsequent paragraphs.

TABLE F-3
Pertinent design data - Meramec Park Reservoir

	Plan I	Plan II (pumped)	Plan III (combined)
Main reservoir			
Top flood control pool	701 m.s.l.	701 m.s.l.	701 m.s.l.
Bottom flood control pool	667 m.s.l.	667 m.s.l.	667 m.s.l.
Operating plan limits total drawdown of joint-use pool to elevation	663 m.s.l.	663 m.s.l.	663 m.s.l.
Daily drawdown limited to	0.6 ft.	0.6 ft.	0.7 ft.
Hilltop pool			
Drainage area	No hilltop pool	1 sq. mi.	1 sq. mi.
Top pool elevation		820 m.s.l.	820 m.s.l.
Area		262 acres	262 acres
Bottom pool elevation		615 m.s.l.	615 m.s.l.
Total storage		19,600 ac.-ft.	19,600 ac.-ft.
Daily release to main reservoir		6,000 ac.-ft.	6,000 ac.-ft.
Daily release to river		0	700 ac.-ft.
Daily drawdown to elevation		796 m.s.l.	792 m.s.l.
Mean pool level		810 m.s.l.	808 m.s.l.
River elevation		565 m.s.l.	565 m.s.l.
Power operation - pumped storage			
Load factor	No pumped storage	25%	10%
Design discharge		12,000 c.f.s.	30,000 c.f.s.
Average net head		140 ft.	138 ft.
Rated installed capacity		120,000 KW	300,000 KW
Minimum head		116 ft.	104 ft.
Dependable capacity		92,000 KW	228,000 KW

TABLE F-3 (Cont'd)

	Plan I	Plan II (pumped)	Plan III (combined)
Power operation - conventional	(Release from reservoir)		(Release from hill-top impoundment)
Load factor	10%		10%
Mean daily discharge	3,500 c.f.s.		3,500 c.f.s.
Average mean head	100 ft.		240 ft.
Rated installed capacity	24,000 KW		60,000 KW

7. DESIGN DETAILS

a. Plan I. The power installation would consist of an intake structure in the right abutment with invert at approximate elevation 600, a powerhouse located on the Meramec River downstream of the dam with one vertical non-reversible turbine unit, and one 1,200-foot long by 17-1/2-foot diameter steel-lined penstock driven through rock in the right abutment. The major items of equipment to be installed in the powerhouse would include the following:

(1) One vertical Kaplan-type hydraulic turbine directly connected to a 24,000-kilowatt synchronous generator.

(2) An overhead traveling crane.

(3) Power switchgear, nominal 15 KV.

b. Plan II. The pumped-storage installation would consist of an intake structure near the top of the adjoining upper reservoir, a powerhouse located on the left bank of the main reservoir with three vertical reversible pump-turbine units, and three 510-foot long by 18-1/2-foot diameter steel-lined penstocks driven through rock. The installation is located at a saddle in the ridge between reservoirs. In order to completely drain the upper reservoir should a leakage condition develop, a 750-foot steel-lined section of tunnel would connect an intake structure at the bottom of the upper reservoir to slide gates located at the bottom of a 15-foot diameter concrete-lined shaft driven through rock, and a 1,350-foot concrete-lined section of tunnel would connect the gate shaft to a stilling basin at the Meramec River downstream of Meramec Park Dam. These details are similar to the power facilities for the pumped-storage features of Plan III, shown on PLATES F-1 and F-2, except for the number and size of the units and excluding the conventional unit shown. The major items of equipment to be installed in the pumped-storage powerhouse include the following:

(1) Three vertical reversible pump turbines each directly connected to a 40,000-kilowatt synchronous generator motor.

(2) An overhead traveling crane.

(3) A compressed air system to provide air for depressing water below the eye of the impeller when starting the motors for pump-back operation.

(4) Power switchgear, nominal 15 KV.

(5) Motor starting bus system.

The power transformers and necessary switching and transmission equipment would be located in the switchyard immediately adjacent to the powerhouse.

c. Plan III (see PLATES F-1 and F-2). The pumped-storage installation would consist of an intake structure near the top of the adjoining upper reservoir, a powerhouse located on the left bank of the main reservoir with two vertical reversible pump-turbine units connected to two 510-foot long by 22-foot diameter steel-lined penstocks driven through rock, and two vertical non-reversible turbine units connected to two 510-foot long by 30-foot diameter steel-lined penstocks driven through rock. The installation is located at a saddle in the ridge between the reservoirs. The conventional power installation consists of an intake structure near the top of the upper storage reservoir, a powerhouse located on the Meramec River downstream of the main dam with one vertical non-reversible turbine unit, and one 1,130-foot long by 17-foot diameter steel-lined penstock driven through rock in the ridge at the right abutment of the upper dam. Provisions for drawing the upper reservoir are the same as in Plan II.

(1) The major items of equipment to be installed in the pumped-storage powerhouse would include the following:

(a) Two vertical Kaplan-type hydraulic turbines each directly connected to a 110,000-kilowatt synchronous generator.

(b) Two vertical reversible pump turbines each directly connected to a 41,000-kilowatt synchronous generator motor.

(c) An overhead traveling crane.

(d) A compressed air system to provide air for depressing water below the eye of the impeller when starting the motors for pump-back operation.

(e) Power switchgear, nominal 15 KV.

(f) Motor starting bus system.

The power transformers and necessary switching and transmission equipment would be located in the switchyard immediately adjacent to the powerhouse.

(2) The major items of equipment to be installed in the conventional powerhouse would include the following:

(a) One vertical Francis-type hydraulic turbine connected to a 60,000-kilowatt synchronous generator.

(b) An overhead traveling crane.

(c) Power switchgear, nominal 15 KV.

A power transformer and the necessary switching and transmission equipment would be located in the switchyard immediately adjacent to the powerhouse.

8. FOUNDATION INVESTIGATIONS

a. Methods and results. Six core borings were driven at the proposed hilltop power dam and reservoir to investigate foundation conditions and supplement reconnaissance studies and explorations at the adjacent major reservoir site. The locations of these borings are shown on PLATE F-1, and the logs are presented on PLATE D-17, APPENDIX D. The results of these explorations indicate that:

(1) The depth to bedrock is extremely variable along the reservoir rim, with maximum depth in the order of 55 feet.

(2) The cherty, clayey, residual soil is very pervious at the damsite abutments, along the reservoir rim, and in the valley section.

(3) The upper portion of the cherty dolomite bedrock is severely weathered, and delineation of unaltered rock is difficult.

(4) The major portion of the dolomite penetrated by the borings leaked consistently.

(5) Some impervious clays cap the alluvial sands at the ravine bottoms.

Field studies have shown the existence of an active sink and interconnected cave at the northwestern extremities of the reservoir.

b. Remedial measures. As shown by these investigations, the following concepts and remedial measures would be required:

(1) Because of the pervious ravine soils, a positive cutoff should extend across the drainage bottom at the power dam axis. A grout curtain on bedrock should be considered in conjunction with the cutoff.

(2) Efficient use of available soils and excavated materials indicates a zoned dam section as shown on PLATE F-1.

(3) Excavation, concrete backfill, and subsequent grouting would be required to seal the cave chambers to offset leakage through the sink.

(4) The porosity of the surface soils on the perimeter of the proposed pool will require positive cutoff to assure against leakage even under the low heads near the reservoir top.

(5) Grouting of the entire perimeter beneath the earth cutoff is indicated to prevent leakage through the narrow ridge bedrock.

A detailed description of the power site foundation conditions is contained in APPENDIX D.

SECTION III - DESIGN DATA - PINE FORD

9. HEAD AND DISCHARGE DATA

The following data are presented for the pumped-storage hydropower plans studied:

TABLE F-4
Pertinent design data - Pine Ford Reservoir

	Plan I	Plan II
Main reservoir		
Top flood control pool	595 m.s.l.	595 m.s.l.
Bottom flood control pool	561 m.s.l.	561 m.s.l.
Bottom joint-use pool	531 m.s.l.	531 m.s.l.
Operating plan limits total drawdown of joint-use pool to	557 m.s.l.	557 m.s.l.
Storage 561 to 557	13,300 ac.-ft.	13,300 ac.-ft.
Operating plan limits daily drawdown to	2 ft.	2 ft.
Average available storage for pumping	7,000 ac.-ft.	7,000 ac.-ft.
Hilltop pool		
Drainage area	2 sq. mi.	2 sq. mi.
Top pool elevation	720 m.s.l.	720 m.s.l.
Area	1,420 ac.	1,420 ac.
Bottom pool elevation	500 m.s.l.	500 m.s.l.
Total storage	97,000 ac.-ft.	97,000 ac.-ft.
Daily release	7,000 ac.-ft.	7,000 ac.-ft.
Daily drawdown to	715 m.s.l.	715 m.s.l.
Mean pool level	718 m.s.l.	718 m.s.l.
Power operation		
Daily operation	6 hrs.	2.4 hrs.
Load factor	25%	10%
Design discharge	14,000 c.f.s.	35,000 c.f.s.
Average net head	155 ft.	155 ft.
Rated installed capacity	160,000 KW	400,000 KW

10. DESIGN DETAILS

a. Plan I. With a plant designed for 25 percent load factor, the pumped-storage installation would consist of an intake structure near the top of the upper reservoir, a powerhouse located along the left bank of the main reservoir with four vertical reversible pump-turbine units, and four 1,830-foot long by 17-foot diameter steel-lined penstocks driven through rock in the ridge between reservoirs. The arm of the main reservoir is excavated to provide an approach channel to the powerhouse, and the channel walls are faced with concrete. See PLATE F-3. Provisions for draining the upper reservoir for repairs should a leakage condition develop would consist of a 6-foot diameter tunnel driven through rock in the left abutment. A 700-foot steel-lined section of tunnel would connect an intake structure at the bottom of the pumped-storage reservoir to slide gates located at the bottom of an 18-foot diameter concrete-lined shaft driven through rock. A 1,000-foot concrete-lined section of tunnel would connect the gate shaft to a stilling basin at the Big River downstream from the Pine Ford Dam. The major items of equipment to be installed in the pumped-storage powerhouse would include the following:

(1) Four vertical reversible pump turbines each directly connected to a 40,000-kilowatt synchronous generator motor.

(2) An overhead traveling crane.

(3) A compressed air system to provide air for depressing water below the eye of the impeller when starting the motors for pump-back operation.

(4) Power switchgear, nominal 15 KV.

(5) Motor starting bus system.

The power transformers and necessary switching and transmission equipment would be located in the switchyard immediately adjacent to the powerhouse.

b. Plan II. All design details would be similar to Plan I except that nine vertical reversible pump turbines, each directly connected to a 44,400-kilowatt synchronous generator motor, would be installed. Nine 18-foot diameter steel-lined penstocks would be required.

c. Maximum power plan. Preliminary investigations indicated that, owing to the large capacity of the auxiliary upper reservoir, 54,000 acre-feet of water could be recirculated daily from the main

reservoir to the higher impoundment. With a net head of 132 feet, an installation of 990,000 kilowatts would be possible at a 25 percent load factor. However, this would result in an 18-foot daily fluctuation in the main reservoir, which would obviously be unsuitable for recreational use. Consequently, this study was not carried any further.

11. FOUNDATION INVESTIGATIONS

There were no foundation investigations made at the location of the proposed hilltop reservoir site.

SECTION IV - DESIGN DATA - SALEM

12. HEAD AND DISCHARGE DATA

The following data are presented for the pumped-storage hydropower plans studied:

TABLE F-5
Pertinent design data - Salem Reservoir

	Plan I	Plan II
Main reservoir		
Top flood control pool	1,008 m.s.l.	1,008 m.s.l.
Bottom flood control pool (normal pool)	995 m.s.l.	995 m.s.l.
Bottom joint-use pool	928 m.s.l.	928 m.s.l.
Operating plan limits total drawdown of joint-use pool to elevation	969 m.s.l.	969 m.s.l.
Storage 995 to 969	64,300 ac.-ft.	64,300 ac.-ft.
Operating plan limits daily drawdown to	2 ft.	2 ft.
Average available storage for pumping	5,000 ac.-ft.	5,000 ac.-ft.
Hilltop pool		
Drainage area	1.5 sq. mi.	1.5 sq. mi.
Top pool elevation	1,140 m.s.l.	1,140 m.s.l.
Area	570 ac.	570 ac.
Bottom pool elevation	950 m.s.l.	950 m.s.l.
Total storage	35,800 ac.-ft.	35,800 ac.-ft.
Daily release	5,000 ac.-ft.	5,000 ac.-ft.
Daily drawdown to	1,130 m.s.l.	1,130 m.s.l.
Mean pool level	1,136 m.s.l.	1,136 m.s.l.
Power operation		
Daily operation	6 hrs.	2.4 hrs.
Load factor	25%	10%
Design discharge	10,000 c.f.s.	25,000 c.f.s.
Average net head	139 ft.	139 ft.
Rated installed capacity	100,000 KW	250,000 KW

13. DESIGN DETAILS

a. Plan I. The pumped-storage installation would consist of an intake structure near the top of the upper reservoir, a powerhouse located in a ledge along the left bank of the main reservoir with three vertical reversible pump-turbine units, and three 1,500-foot long by 17-foot diameter steel-lined penstocks driven through rock in the ridge between reservoirs. The arm of the main reservoir would be excavated to provide an approach channel to the powerhouse, and the channel walls would be faced with concrete. See PLATE F-4. Provisions for draining the upper reservoir for emergency repairs would consist of a 6-foot diameter tunnel driven through rock in the right abutment. A 1,050-foot steel-lined section of tunnel would connect an intake structure at the bottom of the pumped-storage reservoir to slide gates located at the bottom of an 18-foot diameter concrete-lined shaft driven through rock. A 1,200-foot concrete-lined section of tunnel would connect the gate shaft to a stilling basin at the river downstream of the Salem Dam. The major items of equipment to be installed in the pumped-storage powerhouse would include the following:

(1) Three vertical reversible pump turbines each directly connected to a 34,000-kilowatt synchronous generator motor.

(2) An overhead traveling crane.

(3) A compressed air system to provide air for depressing water below the eye of the impeller when starting the motors for pump-back operation.

(4) Power switchgear, nominal 15 KV.

(5) Motor starting bus system.

The power transformers and necessary switching and transmission equipment would be located in the switchyard immediately adjacent to the powerhouse.

b. Plan II. All design details would be similar to Plan I except that six vertical reversible pump turbines, each directly connected to a 42,000-kilowatt synchronous generator motor, would be installed. Six 19-foot diameter steel-lined penstocks would be required.

c. Maximum power plan. Preliminary investigations indicated that, owing to the large capacity of the auxiliary upper reservoir, 18,000 acre-feet of water could be recirculated daily from the main

reservoir to the higher impoundment. With a net head of 124 feet, an installation of 326,000 kilowatts would be possible at a 25 percent load factor. However, this would result in a 6-foot daily fluctuation in the main reservoir, which would obviously be unsuitable for recreational use. Consequently, this study was not carried any further.

14. FOUNDATION INVESTIGATIONS

There were no foundation investigations made at the location of the proposed hilltop reservoir site.

SECTION V - COST ESTIMATES

15. COST SUMMARY AND DETAILED ESTIMATES

The power plans were investigated only in sufficient detail to determine the specific costs associated with the installed plants. A cost summary for each of these plans is given below in TABLE F-6, and detailed cost estimates follow the summary in TABLE F-7.

TABLE F-6
Cost summary
Power plans investigated

a. Meramec Park

Plan I

Reregulating weir	$ 130,000
Power plant	9,820,000
Access roads	30,000
Engineering and design	590,000
Supervision and administration	630,000
Total Specific Costs $465/KW	$ 11,200,000

3,500 cfs 24,000 KW

Plan II

Lands (400 acres)	46,000
Reservoir clearing	69,000
Dam and saddle dam	19,870,000
Power plant	25,400,000
Access roads	214,000
Engineering and design	2,641,000
Supervision and administration	2,860,000
Total Specific Costs $425/KW	$ 51,100,000

12,000 cfs 120,000 KW

Plan III

Lands (400 acres)	46,000
Reservoir clearing	69,000
Dams and saddle dam	19,870,000
Reregulating weir	130,000
Power plant	55,600,000
Access roads	244,000
Engineering and design	4,160,000
Supervision and administration	4,181,000
Total Specific Costs $280/KW	$ 84,300,000

21,600 mgd. 30,000 cfs 300,000 KW

3500 cfs 60,000 KW

b. Pine Ford

Plan I

Lands (1,420 acres)	112,000
Relocations	180,000
Reservoir clearing	345,000
Dam, including saddle dams	13,213,000
Power plant	39,111,000
Access roads	725,000
Engineering and design	3,160,000
Supervision and administration	3,354,000
Total Specific Costs Only	60,200,000

$376/KW

160,000 KW

14,000 cfs

Plan II

Lands (1,420 acres)	112,000
Relocations	180,000
Reservoir clearing	345,000
Dam, including saddle dams	13,213,000
Power plant	73,956,000
Access roads	725,000
Engineering and design	5,080,000
Supervision and administration	5,189,000
Total Specific Costs Only	98,800,000

22,600 mgd

$247/KW

400,000 KW

35,000 cfs

c. Salem

Plan I

Lands (1,140 acres)	80,000
Reservoir clearing	136,000
Dam, including saddle dams	7,574,000
Power plant	26,338,000
Access Roads	313,000
Engineering and design	2,090,000
Supervision and administration	2,169,000
Total Specific Costs Only	38,700,000

$387/KW

10,000 cfs

100,000 KW

Plan II

Lands (1,140 acres)		$ 80,000
Reservoir clearing		136,000
Dam, including saddle dams		7,574,000
Power plant	16,200 mgd	53,372,000
Access roads		313,000
Engineering and design		3,760,000
Supervision and administration		3,865,000
Total Specific Costs Only	$276/KW	69,100,000

25,000 cfs 250,000 KW

Total 16,200
22,600
21,600
60,400 mgd

TABLE F-7
Detailed cost estimates for power plans investigated

Meramec Park Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
04.	DAMS				($ 130,000)
	Reregulating weir				
	Rock, shovel-run	29,000	ton	2.40	$ 69,600
	Sand, compacted	5,000	ton	3.00	15,000
	Excavation, class A	22,000	cu.yd.	1.00	22,000
	Reinf. concrete pipe 30"	180	lin.ft.	11.55	2,079
	Subtotal for reregulating weir				$ 108,679
	Contingencies				16,321
	Total for reregulating weir				$ 125,000
	Operation and maintenance during construction including contingencies				$ 5,000
	TOTAL FOR DAMS				$ 130,000
07.	POWER PLANT				($ 9,820,000)
	CONVENTIONAL POWER PLANT				
.1	Powerhouse				
	Penstock				
	Excavation, rock tunnel	19,100	cu.yd.	16.00	$ 305,600
	Concrete, reinforced tunnel	10,600	cu.yd.	38.00	402,800
	Steel, structural tunnel (penstock) lining	2,030,000	lb.	.20	406,000
	Steel, structural, tunnel (penstock) lining stiffeners	219,200	lb.	.20	43,840
	Steel, structural, tunnel (penstock) mine plates	330,000	lb.	.20	66,000
	Steel, structural, tunnel (penstock) mine plate supports	511,000	lb.	.20	102,200
	Steel, concrete reinforcement, tunnel	233,000	lb.	.15	34,950
	1-1/2" holes, drilled in rock for grouting	2,400	lin.ft.	4.50	10,800

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	POWER PLANT (Cont'd)				
	Grout tubes (2" standard pipe)	1,380	lin.ft.	3.50	$ 4,830
	Grout, cement	4,800	cu.ft.	5.00	24,000
	Subtotal for penstock				$ 1,401,020
	Structures and improvements				
	Hydraulic plant	sum	job		$ 3,000,000
	Transmission plant	sum	job		150,000
	Subtotal for structures and improvements				$ 3,150,000
	Subtotal for powerhouse				$ 4,551,020
	CONVENTIONAL POWER PLANT				
.2	Turbines and generators				
	Hydraulic plant equipment	sum	job		$ 3,672,000
	Transmission plant equipment	sum	job		367,000
	Subtotal for turbines and generators				$ 4,039,000
	Subtotal				$ 8,590,020
	Contingencies				1,226,980
	Subtotal for conventional power plant				$ 9,817,000
	Operation and maintenance during construction including contingencies				3,000
	TOTAL FOR CONVENTIONAL POWER PLANT				$ 9,820,000
08.	ROADS, RAILROADS AND BRIDGES				($ 30,000)
	Roads				
	Clearing and grubbing	3	acre	$175.00	$ 525
	Stripping	5,200	cu.yd.	.45	2,340
	Excavation	2,200	cu.yd.	1.00	2,200
	Embankment and compaction	700	cu.yd.	.75	525
	Machine grading, class II	15	station	150.00	2,250
	Base material, type I	1,800	ton	2.00	3,600

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	ROADS, RAILROADS AND BRIDGES (Cont'd)				
	Asphaltic concrete	4,500	sq.yd.	2.50	$ 11,250
	Subtotal for roads				$ 22,690
	Contingencies				3,310
	Subtotal for roads, exclusive of right-of-way				$ 26,000
	Right-of-way costs				1,000
	Total costs for roads				$ 27,000
	Subtotal for roads, railroads and bridges				$ 27,000
	Operation and maintenance during construction including contingencies				3,000
	TOTAL FOR ROADS, RAILROADS AND BRIDGES				$ 30,000
30.	ENGINEERING AND DESIGN:				$ 590,000
31.	SUPERVISION AND ADMINISTRATION:				$ 630,000
	TOTAL COST FOR MERAMEC PARK HYDROPOWER PLAN I (July 1963)				$11,200,000

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
01.	LANDS AND DAMAGES				($ 46,000)
	TOTAL LANDS AND DAMAGES INCLUDING CONTINGENCIES	sum	job		$ 46,000
03.	RESERVOIRS				($ 69,000)
	Clearing and grubbing, timbered	300	acre	200.00	$ 60,000
	Subtotal for reservoirs				$ 60,000
	Contingencies				9,000
	TOTAL FOR RESERVOIRS				$ 69,000
04.	DAMS				($19,870,000)
	Main dam				
	Stripping foundation	120,000	cu.yd.	0.45	$ 54,000
	Excavation - core trench	80,900	cu.yd.	0.50	40,450
	Embankment impervious fill	2,050,000	cu.yd.	0.75	1,537,500
	Embankment random fill	731,000	cu.yd.	0.70	511,700
	Sand drain	164,000	ton	1.75	287,000
	Slope protection, dumped rock	2,510,000	ton	3.70	9,287,000
	Piezometers	45	each	270.00	12,150
	Road surfacing, (A-3w/stone)	7,850	sq.yd.	3.60	28,260
	Guardrail	5,890	lin.ft.	3.25	19,143
	Clearing, dam and grass, spillway site	80	acre	175.00	14,000
	Drilling 1-1/2" dia. grout holes	75,000	lin.ft.	4.50	337,500
	Grout	150,000	cu.ft.	5.00	750,000
	Remedial treatment - Bear Cave	sum	job		18,000
	Reservoir perimeter - residual soil treatment				
	Stripping	329,000	cu.yd.	0.45	148,050
	Excavation rock	26,200	cu.yd.	4.00	104,800
	Perimeter drains	41,800	lin.ft.	6.00	250,800

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	DAMS (Cont'd)				
	Sand (for sand drains)	797,000	cu.yd.	1.75	$ 1,394,750
	Asphalt membrane	sum	job		375,000
	Soil cover, semi-compacted	1,411,000	cu.yd.	1.25	1,763,750
	Soil Sterilants	540	acre	300.00	162,000
	Saddle dam				
	Foundation stripping	8,100	cu.yd.	.45	3,645
	Excavation, trench	19,400	cu.yd.	.50	9,700
	Embankment, impervious fill	37,300	cu.yd.	.75	27,975
	Embankment, random fill	24,400	cu.yd.	.70	17,080
	Sand drain	2,350	ton	1.75	4,113
	Bedding material, 6 inches	1,320	ton	3.20	4,224
	Riprap, 18 inches	3,430	ton	3.70	12,691
	Gravel, downstream slope, 6 inches	1,320	ton	2.70	3,564
	Fence, chain link, w/3-strand barbwire and 10' gate	sum	job		48,000
	Subtotal for main dam				$17,226,845
	Contingencies				2,590,155
	Total for main dam				$19,817,000
	Operation and maintenance during construction including contingencies				53,000
	TOTAL FOR DAMS				$19,870,000
07.	POWER PLANT				($25,400,000)
	PUMP STORAGE POWER PLANT				
.1	Powerhouse				
	Penstock				
	Excavation, rock, tunnel	27,000	cu.yd.	16.00	$ 432,000
	Concrete, reinforced, tunnel (penstock)	14,700	cu.yd.	38.00	558,600
	Steel, structural tunnel (penstock) lining	2,730,000	lb.	.20	546,000

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	POWER PLANT (Cont'd)				
	Steel, structural tunnel (penstock) lining stiffeners	295,000	lb.	.20	$ 59,000
	Steel, structural tunnel (penstock) mine plates	459,000	lb.	.20	91,800
	Steel, structural, tunnel (penstock) mine plate supports	772,000	lb.	.20	154,400
	Steel, concrete reinforcement, tunnel	314,000	lb.	.15	47,100
	1-1/2" holes, drilled in rock for grouting	30,600	lin.ft.	4.50	137,700
	Grout tubes (2" standard pipe)	18,400	lin.ft.	3.50	64,400
	Grout, cement	61,200	cu.ft.	5.00	306,000
	Subtotal for penstock				$ 2,397,000
	Hilltop reservoir outlet works				
	Excavation, common	7,000	cu.yd.	.45	$ 3,150
	Excavation, rock, tunnel entrance	1,300	cu.yd.	4.00	5,200
	Excavation, rock, stilling basin	500	cu.yd.	3.50	1,750
	Excavation, rock, tunnel	4,600	cu.yd.	20.00	92,000
	Excavation, rock, control shaft	2,300	cu.yd.	18.00	41,400
	Backfill	800	cu.yd.	1.25	1,000
	Concrete, reinforced tunnel entrance	50	cu.yd.	45.00	2,250
	Concrete, reinforced stilling basin	250	cu.yd.	40.00	10,000
	Concrete, reinforced tunnel lining	3,200	cu.yd.	50.00	160,000
	Concrete, reinforced control shaft lining	1,050	cu.yd.	40.00	42,000
	Steel, structural tunnel lining	440,000	lb.	.20	88,000
	Steel, structural, tunnel lining stiffeners	49,000	lb.	.20	9,800

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	POWER PLANT (Cont'd)				
	Steel, structural, tunnel mine plates	210,000	lb.	.20	$ 42,000
	Steel, structural mine plate supports	220,000	lb.	.20	44,000
	Steel, concrete reinforcing	184,000	lb.	.15	27,600
	1-1/2" holes, drilled in rock for grouting	4,200	lin.ft.	4.50	18,900
	Grout tubes (2" standard pipe)	1,500	lin.ft.	3.50	5,250
	Grout, cement	8,400	cu.ft.	5.00	42,000
	Slide gate, 3' x 7' (220' head) complete	2	each	53,000.00	106,000
	Electrical system	sum	job		5,000
	Subtotal for outlet works				$ 747,300
	Structures and improvements				
	Hydraulic plant	sum	job		$ 8,609,000
	Transmission plant	sum	job		431,000
	Subtotal for structures and improvements				$ 9,040,000
	Subtotal for powerhouse				$12,184,300
.2	Turbine and generators				
	Hydraulic plant equipment	sum	job		$ 8,974,000
	Transmission plant equipment	sum	job		897,000
	Subtotal for turbines and generators				$ 9,871,000
	Subtotal for power plant				$22,055,300
	Contingencies				$ 3,337,700
	Subtotal for power plant				$25,393,000
	Operation and maintenance during construction including contingencies				7,000
	TOTAL FOR POWER PLANT				$25,400,000

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
08.	ROADS, RAILROADS AND BRIDGES				($ 214,000)
	Roads				
	Clearing and grubbing	11	acre	175.00	$ 1,925
	Stripping	18,100	cu.yd.	.45	8,145
	Excavation	8,300	cu.yd.	1.00	8,300
	Embankment and compaction	2,300	cu.yd.	.75	1,725
	Machine grading - class II	62	station	150.00	9,300
	Base material - type I	7,110	ton	2.00	14,220
	Asphaltic concrete surface	18,400	sq.yd.	2.50	46,000
	Subtotal for roads				$ 89,615
	Contingencies				9,385
	Subtotal for roads, exclusive of right-of-way				$ 99,000
	Right-of-way costs				6,000
	Total cost for roads				$ 105,000
	Railroads				
	Switch from main line to siding	sum	job		$ 3,300
	Single track siding	2,400	lin.ft.	11.50	27,600
	Clearing and grubbing storage yard	70	acre	25.00	1,750
	Fence, chain link, 7' high w/3-strand barbed wire top	sum	job		5,880
	Gate, chain link, double 10' x 7'	40	lin.ft.	11.00	440
	Subtotal for railroads				$ 38,970
	Contingencies				6,030
	Subtotal for railroads, exclusive of right-of-way				$ 45,000
	Right-of-way costs				
	Railroad				$ 2,500
	Storage yard				52,500
	Subtotal for right-of-way costs				$ 55,000

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	ROADS, RAILROADS AND BRIDGES (Cont'd)				
	Total cost for railroads				$ 100,000
	Subtotal for roads, railroads and bridges				$ 205,000
	Operation and maintenance during construction including contingencies				$ 9,000
	TOTAL FOR ROADS, RAILROADS AND BRIDGES				$ 214,000
30.	ENGINEERING AND DESIGN				$ 2,641,000
31.	SUPERVISION AND ADMINISTRATION				$ 2,860,000
	TOTAL COST FOR MERAMEC PARK, HYDROPOWER, PLAN II (July 1963)				$51,100,000

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan III

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
01.	LANDS AND DAMAGES				($ 46,000)
	TOTAL LANDS AND DAMAGES INCLUDING CONTINGENCIES	sum	job		$ 46,000
03.	RESERVOIRS				($ 69,000)
	Clearing and grubbing, timbered	300	acre	200.00	$ 60,000
	Subtotal for reservoirs				$ 60,000
	Contingencies				9,000
	TOTAL FOR RESERVOIRS				$ 69,000
04.	DAMS				($20,000,000)
	Main dam				
	Stripping foundation	120,000	cu.yd.	0.45	$ 54,000
	Excavation - core trench	80,900	cu.yd.	0.50	40,450
	Embankment impervious fill	2,050,000	cu.yd.	0.75	1,537,500
	Embankment random fill	731,000	cu.yd.	0.70	511,700
	Sand drain	164,000	ton	1.75	287,000
	Slope protection, dumped rock	2,510,000	ton	3.70	9,287,000
	Piezometers	45	each	270.00	12,150
	Road surfacing, (A-3w/stone)	7,850	sq.yd.	3.60	28,260
	Guardrail	5,890	lin.ft.	3.25	19,143
	Clearing, dam and grass spillway site	80	acre	175.00	14,000
	Drilling 1-1/2" dia. grout holes	75,000	lin.ft.	4.50	337,500
	Grout	150,000	cu.ft.	5.00	750,000
	Remedial treatment - Bear Cave	sum	job		18,000
	Reservoir perimeter - residual soil treatment				
	Stripping	329,000	cu.yd.	0.45	148,050
	Excacation rock	26,200	cu.yd.	4.00	104,800
	Perimeter drains	41,800	lin.ft.	6.00	250,800
	Sand (for sand drains)	797,000	cu.ft.	1.75	1,394,750

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan III

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	DAMS (Cont'd)				
	Asphalt membrane	sum	job		$ 375,000
	Soil cover, semi-compacted	1,411,000	cu.yd.	1.25	1,763,750
	Soil sterilants	540	acre	300.00	162,000
	Saddle dam				
	Foundation stripping	8,100	cu.yd.	.45	3,645
	Excavation, trench	19,400	cu.yd.	.50	9,700
	Embankment, impervious fill	37,300	cu.yd.	.75	27,975
	Embankment, random fill	24,400	cu.yd.	.70	17,080
	Sand drain	2,350	ton	1.75	4,113
	Bedding material, 6 inches	1,320	ton	3.20	4,224
	Riprap, 18 inches	3,430	ton	3.70	12,691
	Gravel, downstream slope, 6 inches	1,320	ton	2.70	3,564
	Fence, chain link, w/3 strand barbwire and 10' gate	sum	job		48,000
	Reregulating weir				
	Rock, shovel-run	29,000	ton	2.40	69,600
	Sand, compacted	5,000	ton	3.00	15,000
	Excavation, class A	22,000	cu.yd.	1.00	22,000
	Reinf. concrete pipe 30"	180	lin.ft.	11.55	2,079
	Subtotal for main dam				$17,335,524
	Contingencies				2,606,476
	Total for main dam				$19,942,000
	Operation and maintenance during construction including contingencies				58,000
	TOTAL FOR DAMS				$20,000,000
07.	POWER PLANT				($55,600,000)
	PUMP STORAGE POWER PLANT				
.1	Powerhouse				
	Penstock				
	Excavation, rock, tunnel, (penstock)	69,800	cu.yd.	16.00	$ 1,116,800
	Concrete, reinf. tunnel (penstock)	28,400	cu.yd.	38.00	1,079,200

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan III

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	POWER PLANT (Cont'd)				
	Steel, structural, tunnel (penstock) lining	5,580,000	lb.	.20	$ 1,116,000
	Steel, structural, tunnel (penstock) lining stiffeners	840,400	lb.	.20	168,080
	Steel, structural, tunnel (penstock) mine plates	867,000	lb.	.20	173,400
	Steel, structural, mine plate supports	1,578,000	lb.	.20	315,600
	Steel, concrete reinforcement	767,000	lb.	.15	115,050
	1-1/2" holes, drilled in rock for grouting	4,100	lin.ft.	4.50	18,450
	Grout tubes (2" standard pipe)	3,200	lin.ft.	3.50	11,200
	Grout, cement	8,200	cu.ft.	5.00	41,000
	Subtotal for penstock				$ 4,154,780
	Hilltop reservoir outlet works				
	Excavation, common	7,000	cu.yd.	.45	$ 3,150
	Excavation, rock, tunnel entrance	1,300	cu.yd.	4.00	5,200
	Excavation, rock, stilling basin	500	cu.yd.	3.50	1,750
	Excavation, rock, tunnel	4,600	cu.yd.	20.00	92,000
	Excavation, rock, control shaft	2,300	cu.yd.	18.00	41,400
	Backfill	800	cu.yd.	1.25	1,000
	Concrete, reinforced, tunnel entrance	50	cu.yd.	45.00	2,250
	Concrete, reinforced, stilling basin	250	cu.yd.	40.00	10,000
	Concrete, reinforced, tunnel lining	3,200	cu.yd.	50.00	$ 160,000
	Concrete, reinforced, control shaft lining	1,050	cu.yd.	40.00	42,000
	Steel, structural, tunnel lining	440,000	lb.	.20	88,000

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan III

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	POWER PLANT (Cont'd)				
	Steel, structural, tunnel lining stiffeners	49,000	lb.	.20	$ 9,800
	Steel, structural, tunnel mine plates	210,000	lb.	.20	42,000
	Steel, structural, mine plate supports	220,000	lb.	.20	44,000
	Steel, concrete reinforcing	184,000	lb.	.15	27,600
	1-1/2" holes, drilled in rock for grouting	4,200	lin.ft.	4.50	18,900
	Grout tubes (2" standard pipe)	1,500	lin.ft.	3.50	5,250
	Grout, cement	8,400	cu.ft.	5.00	42,000
	Slide gate, 3' x 7' (220' head) complete	2	each	53,000.00	106,000
	Electrical system	sum	job		5,000
	Subtotal for outlet works				$ 747,300
	Structures and improvements				
	Hydraulic plant	sum	job		$13,146,000
	Transmission plant	sum	job		657,000
	Subtotal for structures and improvements				$13,803,000
	Subtotal for powerhouse				$18,705,080
.2	Turbine and generators				
	Hydraulic plant equipment	sum	job		$17,842,000
	Transmission plant equipment	sum	job		1,784,000
	Subtotal for turbines and generators				$19,626,000
	Subtotal for pump storage power plant				$38,331,080
	CONVENTIONAL POWER PLANT				
.1	Powerhouse				
	Penstock				
	Excavation, rock, tunnel (penstock)	16,900	cu.yd.	16.00	$ 270,400

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan III

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	CONVENTIONAL POWER PLANT (Cont'd)				
	Concrete, reinforceing, tunnel (penstock)	7,300	cu.yd.	16.00	$ 277,400
	Steel, structural, tunnel (penstock) lining	1,860,000	lb.	.20	372,000
	Steel, structural, tunnel (penstock) lining stiffeners	151,000	lb.	.20	30,200
	Steel, structural, tunnel (penstock) mine plates	311,000	lb.	.20	62,200
	Steel, structural, tunnel (penstock) mine plate supports	470,000	lb.	.20	94,000
	Steel, concrete reinforcement	212,000	lb.	.15	31,800
	1-1/2" holes, drilled in rock for grouting	2,250	lin.ft.	4.50	10,125
	Grout tubes (2" standard pipe)	1,250	lin.ft.	3.50	4,375
	Grout, cement	4,500	cu.ft.	5.00	22,500
	Subtotal for penstock				$ 1,175,000
	Structures and improvements				
	Hydraulic plant	sum	job		$ 3,579,000
	Transmission plant	sum	job		179,000
	Subtotal for structures and improvements				$ 3,758,000
	Subtotal for powerhouse				$ 4,933,000
.2	Turbines and generators				
	Hydraulic plant equipment				$ 4,603,000
	Transmission plant equipment				460,000
	Subtotal for turbines and generators				$ 5,063,000
	Subtotal for conventional power plant				$ 9,996,000

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan III

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	CONVENTIONAL POWER PLANT (Cont'd)				
	Subtotal for power plant				$48,327,080
	Contingencies				7,248,920
	Subtotal for power plant				$55,576,000
	Operation and maintenance during construction including contingencies				24,000
	TOTAL FOR POWER PLANT				$55,600,000
08.	ROADS, RAILROADS AND BRIDGES				($ 244,000)
	Roads				
	Clearing and grubbing	14	acre	175.00	$ 2,450
	Stripping	23,300	cu.yd.	.45	10,485
	Excavation	10,500	cu.yd.	1.00	10,500
	Embankment and compaction	3,000	cu.yd.	.75	2,250
	Machine grading - class II	77	station	150.00	11,550
	Base material - type I	8,910	ton	2.00	17,820
	Asphaltic concrete surface	22,900	sq.yd.	2.50	57,250
	Subtotal for roads				$ 112,305
	Contingencies				12,695
	Subtotal for roads, exclusive of right-of-way				$ 125,000
	Right-of-way costs				7,000
	Total cost for roads				$ 132,000
	Railroads				
	Switch from main line to siding	sum	job		$ 3,300
	Single track siding	2,400	lin.ft.	11.50	27,600
	Clearing and grubbing storage yard	70	acre	25.00	1,750
	Fence, chain link, 7' high w/3-strand barbed wire top	sum	job		5,880

TABLE F-7 (Cont'd)

Meramec Park Reservoir, Hydropower, Plan III

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	ROADS, RAILROADS AND BRIDGES (Cont'd)				
	Gate, chain link, double 10' x 7'	40	lin.ft.	11.00	$ 440
	Subtotal for railroads				$ 38,970
	Contingencies				6,030
	Subtotal for railroads, exclusive of right-of-way				$ 45,000
	Right-of-way costs				
	Railroad				$ 2,500
	Storage yard				52,500
	Subtotal for right-of-way costs				$ 55,000
	Total cost for railroads				$ 100,000
	Subtotal for roads, railroads and bridges				$ 232,000
	Operation and maintenance during construction including contingencies				12,000
	TOTAL FOR ROADS, RAILROADS AND BRIDGES				$ 244,000
30.	ENGINEERING AND DESIGN				$ 4,160,000
31.	SUPERVISION AND ADMINISTRATION				$ 4,181,000
	TOTAL COST FOR MERAMEC PARK, HYDROPOWER, PLAN III (July 1963)				$84,300,000

TABLE F-7 (Cont'd)

Pine Ford Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
01.	LANDS AND DAMAGES				$ 112,000)
	Total lands and damages, including contingencies				112,000
	TOTAL FOR LANDS AND DAMAGES				$ 112,000
02.	RELOCATIONS				($ 180,000)
.1	Roads				
	A-1, relocate Highway "WW"				
	Clearing and grubbing	21	acre	175.00	$ 3,675
	Stripping	34,300	cu.yd.	0.45	15,435
	Excavation, class A	7,200	cu.yd.	1.00	7,200
	Seeding and fertilizer	14	acre	200.00	2,800
	Machine grading, class I	58	station	110.00	6,380
	Machine grading, class II	58	station	150.00	8,700
	Fence, 4-strand barbed wire w/wd posts	26,000	lin.ft.	1.75	45,500
	Base material, type I	10,220	ton	4.50	45,990
	Bituminous road mix (A-3)	29,300	sq.yd.	0.45	13,185
	Subtotal for roads				$ 148,865
	Contingencies				22,135
	Subtotal for roads, exclusive of right-of-way				$ 171,000
	Right-of-way costs				4,000
	Subtotal for roads				$ 175,000
	Operation and maintenance during construction, including contingencies				5,000
	Total for roads				$ 180,000
	TOTAL FOR RELOCATIONS				$ 180,000
03.	RESERVOIRS				($ 345,000)
	Clearing and grubbing	1,500	acre	200.00	300,000
	Subtotal for reservoirs				$ 300,000
	Contingencies				45,000
	TOTAL FOR RESERVOIRS				$ 345,000

TABLE F-7 (Cont'd)

Pine Ford Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
04.	DAMS				($13,213,000)
	Main dam				
	Pervious fill	1,850,000	cu.yd.	0.65	$ 1,202,500
	Select clay	527,000	cu.yd.	1.40	737,800
	Random fill, pervious	3,950,000	cu.yd.	0.70	2,765,000
	Random fill, impervious	501,000	cu.yd.	0.75	375,750
	Select, impervious	2,250,000	cu.yd.	1.40	3,150,000
	Sand drain	111,000	ton	1.75	194,250
	Foundation stripping	885,000	cu.yd.	0.45	398,250
	Core trench excavation	737,000	cu.yd.	1.00	737,000
	Riprap	119,700	ton	3.70	442,890
	Bedding material	40,000	ton	3.20	128,000
	Gravel	59,000	ton	2.70	159,300
	Crushed stone surfacing	8,300	ton	2.70	22,410
	Reservoir fencing				
	Fence, chain link 7' high w/3-strand barbed wire top	37,200	lin.ft.	2.80	104,160
	Gates - 10'W x 7'H chain link	10	each	110.00	1,100
	Foundation grouting, axis of dam				
	1-1/2" holes, drilled in rock for grouting	39,600	lin.ft.	4.50	178,200
	Grout, cement	39,600	cu. ft.	5.00	198,000
	Foundation grouting tie-in dikes				
	1-1/2" holes, drilled in rock for grouting	65,400	lin.ft.	4.50	294,300
	Grout, cement	65,400	cu. ft.	5.00	327,000
	Piezometers	86	each	270.00	23,220
	Subtotal				$11,439,130
	Contingencies				1,715,870
	Subtotal for main dam				$13,155,000
	Operation and maintenance during construction, including contingencies				58,000
	TOTAL FOR DAMS				$13,213,000

R Apr 64

TABLE F-7 (Cont'd)

Pine Ford Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
07.	POWER PLANT				($39,111,000)
.1	Powerhouse				
	Penstock				
	Excavation, rock, tunnel (penstock)	109,300	cu.yd.	16.00	$ 1,748,800
	Concrete, reinforced, tunnel (penstock)	46,900	cu.yd.	38.00	1,782,200
	Steel, structural, tunnel (penstock) lining	12,012,000	lb.	0.20	2,402,400
	Steel, structural, tunnel (penstock) lining stiffeners	1,120,000	lb.	0.20	224,000
	Steel, structural, tunnel (penstock) mine plates	2,015,000	lb.	0.20	403,000
	Steel, structural, tunnel (penstock) mine plate supports	2,725,000	lb.	0.20	545,000
	Steel, concrete reinforcement, tunnel	1,139,000	lb.	0.15	170,850
	1-1/2" holes, drilled in rock for grouting	14,660	lin.ft.	4.50	65,970
	Grout tubes (2" standard pipe)	8,090	lin.ft.	3.50	28,315
	Grout, cement	29,320	cu.ft.	5.00	146,600
	Subtotal for penstock				$ 7,517,135
	Channel connecting powerhouse to main dam reservoir				
	Excavation, common, channel	214,200	cu.yd.	0.45	$ 96,390
	Excavation, rock channel	419,300	cu.yd.	4.00	1,677,200
	Concrete, lightly reinforced, rock cut facing	3,260	cu.yd.	42.00	136,920
	Steel, concrete reinforcing, rock cut facing	163,000	lb.	0.15	24,450

TABLE F-7 (Cont'd)

Pine Ford Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	POWER PLANT (Cont'd)				
	Anchors, rock cut facing each anchor consists of 1- #11 reinforcing bar 14'-8" long (wt. 78#) grouted into 4" dia. hole drilled 10' into rock	490	each	45.50	$ 22,295
	Subtotal for channel				$ 1,957,255
	Reservoir outlet works				
	Excavation, common	6,300	cu.yd.	0.45	$ 2,835
	Excavation, rock, tunnel entrance	1,460	cu.yd.	4.00	5,840
	Excavation, rock, stilling basin	1,570	cu.yd.	3.50	5,495
	Excavation, rock, tunnel	4,700	cu.yd.	20.00	94,000
	Excavation, rock, control shaft	1,930	cu.yd.	18.00	34,740
	Backfill	870	cu.yd.	1.25	1,088
	Concrete, reinforced tunnel entrance	35	cu.yd.	45.00	1,575
	Concrete, reinforced, stilling basin	320	cu.yd.	40.00	12,800
	Concrete, reinforced, tunnel lining	2,920	cu.yd.	50.00	146,000
	Concrete, reinforced, control shaft lining	825	cu.yd.	40.00	33,000
	Steel, structural, tunnel lining	387,000	lb.	0.20	77,400
	Steel, structural, tunnel lining stiffeners	40,700	lb.	0.20	8,140
	Steel, structural, tunnel mine plate	212,500	lb.	0.20	42,500
	Steel, structural, tunnel mine plate supports	202,000	lb.	0.20	40,400
	Steel, concrete reinforcing	166,500	lb.	0.15	24,975
	1-1/2" holes, drilled in rock for grouting	3,400	lin.ft.	4.50	15,300

TABLE F-7 (Cont'd)

Pine Ford Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	POWER PLANT (Cont'd)				
	Grout tubes (2" standard pipe)	1,270	lin.ft.	3.50	$ 4,445
	Grout, cement	6,800	cu.ft.	5.00	34,000
	Slide gate, 3.5' x 8' (204' head)	2	each	70,000.00	140,000
	Subtotal for outlet works				$ 724,533
	Structures and improvements				
	Hydraulic plant	sum	job		$10,643,000
	Transmission plant	sum	job		529,000
	Subtotal for structures and improvements				$11,172,000
	Subtotal for powerhouse				$21,370,923
.2	Turbines and generators				
	Hydraulic plant and equipment	sum	job		$11,478,000
	Transmission plant and equipment	sum	job		1,148,000
	Subtotal for turbines and generators				$12,626,000
	Subtotal for power plant				33,996,923
	Contingencies				5,103,077
	Subtotal for power plant				$39,100,000
	Operation and maintenance during construction, including contingencies				11,000
	TOTAL FOR POWER PLANT				$39,111,000
08.	ROADS, RAILROADS AND BRIDGES				($ 725,000)
	Roads				
	Strengthen Highway Y from Highway 30 to Grubville				
	Embankment	1,600	cu.yd.	0.60	$ 960
	Machine grading, class I	85	station	110.00	9,350
	Bituminous asphaltic concrete w/stone base	9,800	sq.yd.	6.90	67,620
	Subtotal				$ 77,930

TABLE F-7 (Cont'd)

Pine Ford Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	ROADS, RAILROADS AND BRIDGES (Cont'd)				
	Road from Grubville to powerhouse				
	Clearing and grubbing	17	acre	175.00	$ 2,975
	Stripping	14,700	cu.yd.	0.45	6,615
	Embankment	104,000	cu.yd.	0.60	62,400
	Excavation, class A	29,200	cu.yd.	1.00	29,200
	Machine grading, class I	99	station	110.00	10,890
	Bituminous asphaltic concrete w/stone base	48,300	sq.yd.	6.90	333,270
	Subtotal				$ 445,350
	Road from Highway Y to left abutment area				
	Machine grading, class I	16	station	110.00	1,760
	Machine grading, class II	16	station	150.00	2,400
	Surface aggregate	1,700	ton	4.50	7,650
	Subtotal				$ 11,810
	Subtotal for roads				$ 535,090
	Contingencies				80,110
	Subtotal for roads, exclusive of right-of-way				$ 615,200
	Right-of-way costs				
	Highway Y				$ 1,600
	Road to powerhouse				none
	Road to left abutment area				1,200
	Subtotal for right-of-way costs				$ 2,800
	Total for roads				$ 618,000
	Railroads				
	Switch from main line to siding	sum	job		$ 3,300
	Single track siding	2,500	lin.ft.	11.50	28,750
	Clearing and grubbing storage yard	45	acre	25.00	1,125
	Fence, chain link, 7' high w/3-strand barbed wire top, 6,000'	sum	job		17,100

TABLE F-7 (Cont'd)

Pine Ford Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	ROADS, RAILROADS AND BRIDGES (Cont'd)				
	Gate, chain link, double 10' x 7'	40	lin.ft.	11.00	$ 440
	Subtotal for railroads				$ 50,715
	Contingencies				7,285
	Subtotal for railroads, exclusive of right-of-way				$ 58,000
	Right-of-way costs				
	Railroad				$ 1,800
	Storage yard				34,200
	Subtotal for right-of-way costs				$ 36,000
	Total cost for railroads				$ 94,000
	Subtotal for roads, railroads and bridges				$ 712,000
	Operation and maintenance during construction, including contingencies				13,000
	TOTAL FOR ROADS, RAILROADS, AND BRIDGES				$ 725,000
30.	ENGINEERING AND DESIGN				$ 3,160,000
31.	SUPERVISION AND ADMINISTRATION				$ 3,354,000
	TOTAL COST FOR PINE FORD, HYDROPOWER, PLAN I (July 1963)				$60,200,000

TABLE F-7 (Cont'd)

Pine Ford Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
01.	LANDS AND DAMAGES				($ 112,000)
	Total lands and damages, including contingencies				$ 112,000
	TOTAL FOR LANDS AND DAMAGES				$ 112,000
02.	RELOCATIONS				($ 180,000)
.1	Roads				
	A-1, relocate Highway "WW"				
	Clearing and grubbing	21	acre	175.00	$ 3,675
	Stripping	34,300	cu.yd.	0.45	15,435
	Excavation, class A	7,200	cu.yd.	1.00	7,200
	Seeding and fertilizer	14	acre	200.00	2,800
	Machine grading, class I	58	station	110.00	6,380
	Machine grading, class II	58	station	150.00	8,700
	Fence, 4-strand barbed wire w/wd posts	26,000	lin.ft.	1.75	45,500
	Base material, type I	10,220	ton	4.50	45,990
	Bituminous road mix (A-3)	29,300	sq.yd.	0.45	13,185
	Subtotal for roads				$ 148,865
	Contingencies				22,135
	Subtotal for roads, exclusive of right-of-way				$ 171,000
	Right-of-way costs				4,000
	Subtotal for roads				$ 175,000
	Operation and maintenance during construction, including contingencies				5,000
	Total for roads				$ 180,000
	TOTAL FOR RELOCATIONS				$ 180,000
03.	RESERVOIRS				($ 345,000)
	Clearing and grubbing	1,500	acre	200.00	$ 300,000
	Subtotal for reservoirs				$ 300,000
	Contingencies				45,000
	TOTAL FOR RESERVOIRS				$ 345,000

TABLE F-7 (Cont'd)

Pine Ford Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
04.	DAMS				($13,213,000)
	Main dam				
	Pervious fill	1,850,000	cu.yd.	0.65	$ 1,202,500
	Select clay	527,000	cu.yd.	1.40	737,800
	Random fill, pervious	3,950,000	cu.yd.	0.70	2,765,000
	Random fill, impervious	501,000	cu.yd.	0.75	375,750
	Select, impervious	2,250,000	cu.yd.	1.40	3,150,000
	Sand drain	111,000	ton	1.75	194,250
	Foundation stripping	885,000	cu.yd.	0.45	398,250
	Core trench excavation	737,000	cu.yd.	1.00	737,000
	Riprap	119,700	ton	3.70	442,890
	Bedding material	40,000	ton	3.20	128,000
	Gravel	59,000	ton	2.70	159,300
	Crushed stone surfacing	8,300	ton	2.70	22,410
	Reservoir fencing				
	Fence, chain link 7' high w/3-strand barbed wire top	37,200	lin.ft.	2.80	104,160
	Gates - 10'W x 7'H chain link	10	each	110.00	1,100
	Foundation grouting, axis of dam				
	1-1/2" holes, drilled in rock for grouting	39,600	lin.ft.	4.50	178,200
	Grout, cement	39,600	cu. ft.	5.00	198,000
	Foundation grouting tie-in dikes				
	1-1/2" holes, drilled in rock for grouting	65,400	lin.ft.	4.50	294,300
	Grout, cement	65,400	cu. ft.	5.00	327,000
	Piezometers	86	each	270.00	23,220
	Subtotal				$11,439,130
	Contingencies				1,715,870
	Subtotal for main dam				$13,155,000
	Operation and maintenance during construction, including contingencies				58,000
	TOTAL FOR DAMS				$13,213,000

R Apr 64

TABLE F-7 (Cont'd)

Pine Ford Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
07.	POWER PLANT				($73,956,000)
.1	Powerhouse				
	Penstock				
	Excavation, rock, tunnel	274,000	cu.yd.	16.00	$ 4,384,000
	Concrete, reinforced, tunnel	116,300	cu.yd.	38.00	4,419,400
	Steel, structural, tunnel lining	28,630,000	lb.	0.20	5,726,000
	Steel, structural, tunnel lining stiffeners	2,653,000	lb.	0.20	530,600
	Steel, structural, tunnel mine plates	4,950,000	lb.	0.20	990,000
	Steel, structural, tunnel mine plate supports	8,080,000	lb.	0.20	1,616,000
	Steel, concrete reinforcement, tunnel	3,280,000	lb.	0.15	492,000
	1-1/2" holes, drilled in rock for grouting	33,000	lin.ft.	4.50	148,500
	Grout tubes (2" standard pipe)	19,000	lin.ft.	3.50	66,500
	Grout, cement	66,000	cu.ft.	5.00	330,000
	Subtotal for penstock				$18,703,000
	Channel connecting powerhouse to main dam reservoir				
	Excavation, common, channel	540,000	cu.ft.	0.45	243,000
	Excavation, rock, channel	1,057,000	cu.yd.	4.00	4,228,000
	Concrete, lightly reinforced, rock cut facing	8,220	cu.yd.	42.00	345,240
	Steel, concrete reinforcing, rock cut facing	411,000	lb.	0.15	61,650

TABLE F-7 (Cont'd)

Pine Ford Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	POWER PLANT (Cont'd)				
	Anchors, rock cut facing, each anchor consists of one #11 reinforcing bar 14'-8" long (wt. 78#) grouted into 4" dia. hole drilled 10' into rock	1,230	each	45.50	$ 55,965
	Subtotal for channel				$ 4,933,855
	Reservoir outlet works				
	Excavation, common	6,300	cu.yd.	0.45	$ 2,835
	Excavation, rock, tunnel entrance	1,460	cu.yd.	4.00	5,840
	Excavation, rock, stilling basin	1,570	cu.yd.	3.50	5,495
	Excavation, rock, tunnel	4,700	cu.yd.	20.00	94,000
	Excavation, rock, control shaft	1,930	cu.yd.	18.00	34,740
	Backfill	870	cu.yd.	1.25	1,088
	Concrete, reinforced, tunnel entrance	35	cu.yd.	45.00	1,575
	Concrete, reinforced, stilling basin	320	cu.yd.	40.00	12,800
	Concrete, reinforced, tunnel lining	2,920	cu.yd.	50.00	146,000
	Concrete, reinforced, control shaft lining	825	cu.yd.	40.00	33,000
	Steel, structural, tunnel lining	387,000	lb.	0.20	77,400
	Steel, structural, tunnel lining stiffeners	40,700	lb.	0.20	8,140
	Steel, structural, tunnel mine plates	212,500	lb.	0.20	42,500
	Steel, structural, tunnel mine plate supports	202,000	lb.	0.20	40,400
	Steel, concrete reinforcing	166,500	lb.	0.15	24,975
	1-1/2" holes, drilled in rock, for grouting	3,400	lin.ft.	4.50	15,300

TABLE F-7 (Cont'd)

Pine Ford Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	POWER PLANT (Cont'd)				
	Grout tubes (2" standard pipe)	1,270	lin.ft.	3.50	$ 4,445
	Grout, cement	6,800	cu.ft.	5.00	34,000
	Slide gate, 3.5' x 8' (204' head)	2	each	70,000.00	140,000
	Subtotal for outlet works				$ 724,533
	Structures and improvements				
	Hydraulic plant	sum	job		$16,522,000
	Transmission plant	sum	job		835,000
	Subtotal for structures and improvements				$17,357,000
	Subtotal for powerhouse				$41,718,388
.2	Turbines and generators				
	Hydraulic plant and equipment	sum	job		$20,522,000
	Transmission plant and equipment	sum	job		2,052,000
	Subtotal for turbines and generators				$22,574,000
	Subtotal for power plant				$64,292,388
	Contingencies				9,647,612
	Subtotal for power plant				$73,940,000
	Operation and maintenance during construction including contingencies				16,000
	TOTAL FOR POWER PLANT				$73,956,000
08.	ROADS, RAILROADS AND BRIDGES				($ 725,000)
	Roads				
	Strengthen Highway Y from Highway 30 to Grubville				
	Embankment	1,600	cu.yd.	0.60	$ 960
	Machine grading, class I	85	station	110.00	9,350

TABLE F-7 (Cont'd)

Pine Ford Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	ROADS, RAILROADS AND BRIDGES (Cont'd)				
	Bituminous asphaltic concrete w/stone base	9,800	sq.yd.	6.90	$ 67,620
	Subtotal				$ 77,930
	Road from Grubville to powerhouse				
	Clearing and grubbing	17	acre	175.00	$ 2,975
	Stripping	14,700	cu.yd.	0.45	6,615
	Embankment	104,000	cu.yd.	0.60	62,400
	Excavation, class A	29,200	cu.yd.	1.00	29,200
	Machine grading, class I	99	station	110.00	10,890
	Bituminous asphaltic concrete w/stone base	48,300	sq.yd.	6.90	333,270
	Subtotal				$ 445,350
	Road from Highway Y to left abutment area				
	Machine grading, class I	16	station	110.00	$ 1,760
	Machine grading, class II	16	station	150.00	2,400
	Surface aggregate	1,700	ton	4.50	7,650
	Subtotal				$ 11,810
	Subtotal for roads				$ 535,090
	Contingencies				80,110
	Subtotal for roads, exclusive of right-of-way				$ 615,200
	Right-of-way costs				
	Highway Y				$ 1,600
	Road to powerhouse				none
	Road to left abutment area				1,200
	Subtotal for right-of-way costs				$ 2,800
	Total for roads				$ 618,000

TABLE F-7 (Cont'd)

Pine Ford Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	Railroads				
	Switch from main line to siding	sum	job		$ 3,300
	Single track siding	2,500	lin.ft.	11.50	28,750
	Clearing and grubbing storage yard	45	acre	25.00	1,125
	Fence, chain link, 7' high w/3-strand barbed wire top, 6,000'	sum	job		17,100
	Gate, chain link, double 10' x 7'	40	lin.ft.	11.00	440
	Subtotal for railroads				$ 50,715
	Contingencies				7,285
	Subtotal for railroads, exclusive of right-of-way				$ 58,000
	Right-of-way costs				
	Railroad				$ 1,800
	Storage yard				34,200
	Subtotal for right-of-way costs				$ 36,000
	Total cost for railroads				$ 94,000
	Subtotal for roads, railroads and bridges				$ 712,000
	Operation and maintenance during construction, including contingencies				13,000
	TOTAL FOR ROADS, RAILROADS AND BRIDGES				$ 725,000
30.	ENGINEERING AND DESIGN				$ 5,080,000
31.	SUPERVISION AND ADMINISTRATION				$ 5,189,000
	TOTAL COST FOR PINE FORD, HYDROPOWER, PLAN II (July 1963)				$98,800,000

TABLE F-7 (Cont'd)

Salem Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
01.	LANDS AND DAMAGES				($ 80,000)
	Total lands and damages, including contingencies				$ 80,000
	TOTAL FOR LANDS AND DAMAGES				$ 80,000
03.	RESERVOIRS				($ 136,000)
	Clearing and grubbing	590	acre	200.00	118,000
	Subtotal for reservoirs				$ 118,000
	Contingencies				18,000
	TOTAL FOR RESERVOIRS				$ 136,000
04.	DAMS				($ 7,574,000)
	Main dam				
	Impervious fill	4,218,000	cu.yd.	0.75	$ 3,163,500
	Random fill	1,953,000	cu.yd.	0.70	1,367,100
	Trench excavation	266,000	cu.yd.	1.00	266,000
	Foundation stripping	221,000	cu.yd.	0.45	99,450
	Sand drain	478,000	ton	1.75	836,500
	Riprap	66,000	ton	3.70	244,200
	Bedding material	14,000	ton	3.20	44,800
	Gravel	41,000	ton	2.70	110,700
	Crushed stone surfacing	46,000	ton	2.70	124,200
	1-1/2" holes, drilled in rock for grouting	19,000	lin.ft.	4.50	85,500
	Grout cement	19,000	cu. ft.	5.00	95,000
	Remedial treatment, dolomite foundation in ravines				
	1-1/2" holes, drilled in rock for grouting	1,900	lin.ft.	4.50	8,550
	Grout cement	1,900	cu. ft.	5.00	9,500
	Reservoir fencing				
	Fence, chain link 7' high w/3-strand barbed wire top	25,600	lin.ft.	2.80	71,680
	Gate, 10' wide x 7' high chain link	7	each	110.00	770
	Piezometers	80	each	270.00	21,600

TABLE F-7 (Cont'd)

Salem Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	DAMS (Cont'd)				
	Subtotal				$ 6,549,050
	Contingencies				981,950
	Subtotal for main dam				$ 7,531,000
	Operation and maintenance during construction, including contingencies				43,000
	TOTAL FOR DAMS				$ 7,574,000
07.	POWER PLANT				($26,338,000)
.1	Powerhouse				
	Penstock				
	Excavation, rock tunnel	67,300	cu.yd.	16.00	$ 1,076,800
	Concrete, reinforced tunnel	28,800	cu.yd.	38.00	1,094,400
	Steel, structural, tunnel lining	7,395,000	lb.	0.20	1,479,000
	Steel, structural, tunnel lining stiffeners	801,200	lb.	0.20	160,240
	Steel, structural, tunnel mine plates	1,240,000	lb.	0.20	248,000
	Steel, structural, tunnel mine plate supports	1,675,000	lb.	0.20	335,000
	Steel, concrete reinforcement, tunnel	718,000	lb.	0.15	107,700
	1-1/2" holes, drilled in rock for grouting	9,020	lin.ft.	4.50	40,590
	Grout tube (2" standard pipe)	4,980	lin.ft.	3.50	17,430
	Grout, cement	18,040	cu.ft.	5.00	90,200
	Subtotal for penstock				$ 4,649,360
	Channel connecting powerhouse to main dam reservoir				
	Excavation, common, channel	85,420	cu.yd.	0.45	38,439
	Excavation, rock, channel	193,000	cu.yd.	4.00	772,000

TABLE F-7 (Cont'd)

Salem Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	POWER PLANT (Cont'd)				
	Concrete, lightly reinforced, rock cut facing	4,030	cu.yd.	42.00	$ 169,260
	Steel, concrete, reinforcing, rock cut facing	201,500	lb.	0.15	30,225
	Anchors, rock cut facing, each anchor consists of one #11 reinforcing bar 14'-8" long (wt. 78#) grouted into 4" dia. hole drilled 10' into rock	605	each	45.50	27,528
	Subtotal for channel				$ 1,037,452
	Reservoir outlet works				
	Excavation, common	6,300	cu.yd.	0.45	2,835
	Excavation, rock, tunnel entrance	1,460	cu.yd.	4.00	5,840
	Excavation, rock, stilling basin	1,570	cu.yd.	3.50	5,495
	Excavation, rock, tunnel	6,200	cu.yd.	20.00	124,000
	Excavation, rock, control shaft	2,070	cu.yd.	18.00	37,260
	Backfill	870	cu.yd.	1.25	1,088
	Concrete, reinforced, tunnel entrance	35	cu.yd.	45.00	1,575
	Concrete, reinforced, stilling basin	320	cu.yd.	40.00	12,800
	Concrete, reinforced, tunnel lining	3,870	cu.yd.	50.00	193,500
	Concrete, reinforced, control shaft lining	840	cu.yd.	40.00	33,600
	Steel, structural, tunnel lining	406,600	lb.	0.20	81,320
	Steel, structural, tunnel lining stiffeners	42,700	lb.	0.20	8,540
	Steel, structural, tunnel mine plates	281,300	lb.	0.20	56,260
	Steel, structural, tunnel mine plate supports	267,500	lb.	0.20	53,500

TABLE F-7 (Cont'd)

Salem Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	POWER PLANT (Cont'd)				
	Steel, concrete reinforcing	186,800	lb.	0.15	$ 28,020
	1-1/2" holes, drilled in rock for grouting	4,500	lin.ft.	4.50	20,250
	Grout tubes (2" standard pipe)	1,680	lin.ft.	3.50	5,880
	Grout, cement	9,000	cu.ft.	5.00	45,000
	Slide gate, 3.5' x 8' (197' head)	2	each	70,000.00	140,000
	Subtotal for outlet works				$ 856,763
	Structures and improvements				
	Hydraulic plant	sum	job		7,700,000
	Transmission plant	sum	job		385,000
	Subtotal for structures and improvements				$ 8,085,000
	Subtotal for powerhouse				$14,628,575
.2	Turbines and generators				
	Hydraulic plant equipment	sum	job		$ 7,880,000
	Transmission plant equipment	sum	job		385,000
	Subtotal for turbines and generators				$ 8,265,000
	Subtotal for power plant				$22,893,575
	Contingencies				3,434,425
	Subtotal for power plant				$26,328,000
	Operation and maintenance during plant construction, including contingencies				10,000
	TOTAL FOR POWER PLANT				$26,338,000

TABLE F-7 (Cont'd)

Salem Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
08.	ROADS, RAILROADS AND BRIDGES				($ 313,000)
	Roads				
	Road from storage area to powerhouse				
	Clearing and grubbing	9	acre	175.00	$ 1,575
	Stripping	8,000	cu.yd.	0.45	3,600
	Machine grading, class I	54	station	110.00	5,940
	Bituminous asphaltic concrete w/10" stone base	14,400	sq.yd.	6.90	99,360
	Subtotal				$ 110,475
	Road from powerhouse to right abutment area of dam				
	Clearing and grubbing	5	acre	175.00	875
	Stripping	4,400	cu.yd.	0.45	1,980
	Machine grading, class I	30	station	110.00	3,300
	Surface aggregate, gravel	2,300	ton	3.50	8,050
	Subtotal				$ 14,205
	Road from right abutment to left abutment area				
	Clearing and grubbing	13	acre	175.00	2,275
	Stripping	21,100	cu.yd.	0.45	9,495
	Embankment and compaction	51,000	cu.yd.	0.75	38,250
	Machine grading, class I	46	station	110.00	5,060
	Surface aggregate, gravel	6,500	ton	3.50	22,750
	Subtotal				$ 77,830
	Subtotal for roads				$ 202,510
	Contingencies				30,690
	Subtotal for roads, exclusive of right-of-way				$ 233,200
	Right-of-way costs:				
	Storage area to powerhouse				800
	Powerhouse to right abutment area				800
	From right abutment area to left abutment area				1,200
	Subtotal for right-of-way costs				$ 2,800
	Total cost for roads				$ 236,000

TABLE F-7 (Cont'd)

Salem Reservoir, Hydropower, Plan I

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	ROADS, RAILROADS AND BRIDGES (Cont'd)				
	Switch from main line to siding	sum	job		$ 3,300
	Single track siding	1,500	lin.ft.	11.50	17,250
	Clearing and grubbing, storage yard	50	acre	25.00	1,250
	Fence, chain link, 7' high w/3-strand barbed wire top, 6,000'.	sum	job		17,100
	Gate, chain link, double 10' x 7'	4	each	110.00	440
	Subtotal for railroads				$ 39,340
	Contingencies				5,760
	Subtotal for railroads, exclusive of right-of-way				$ 45,100
	Right-of-way costs:				
	Railroad				$ 900
	Storage yard				25,000
	Subtotal for right-of-way costs				$ 25,900
	Total cost for railroads				$ 71,000
	Subtotal cost for roads, railroads and bridges				$ 307,000
	Operation and maintenance during construction, including contingencies				6,000
	TOTAL FOR ROADS, RAILROADS AND BRIDGES				$ 313,000
30.	ENGINEERING AND DESIGN				$ 2,090,000
31.	SUPERVISION AND ADMINISTRATION				$ 2,169,000
	TOTAL COST FOR SALEM, HYDROPOWER, PLAN I (July 1963)				$38,700,000

TABLE F-7 (Cont'd)

Salem Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
01.	LANDS AND DAMAGES				($ 80,000)
	Total lands and damages, including contingencies				$ 80,000
	TOTAL FOR LANDS AND DAMAGES				$ 80,000
03.	RESERVOIRS				($ 136,000)
	Clearing and grubbing	590	acre	200.00	$ 118,000
	Subtotal for reservoirs				$ 118,000
	Contingencies				18,000
	TOTAL FOR RESERVOIRS				$ 136,000
04.	DAMS				($ 7,574,000)
	Main dam				
	Impervious fill	4,218,000	cu.yd.	0.75	$ 3,163,500
	Random fill	1,953,000	cu.yd.	0.70	1,367,100
	Trench excavation	266,000	cu.yd.	1.00	266,000
	Foundation stripping	221,000	cu.yd.	0.45	99,450
	Sand drain	478,000	ton	1.75	836,500
	Riprap	66,000	ton	3.70	244,200
	Bedding material	14,000	ton	3.20	44,800
	Gravel	41,000	ton	2.70	110,700
	Crushed stone surfacing	46,000	ton	2.70	124,200
	1-1/2" holes, drilled in rock for grouting	19,000	lin.ft.	4.50	85,500
	Grout cement	19,000	cu. ft.	5.00	95,000
	Remedial treatment, dolomite foundation in ravines				
	1-1/2" holes, drilled in rock for grouting	1,900	lin.ft.	4.50	8,550
	Grout cement	1,900	cu. ft.	5.00	9,500
	Reservoir fencing				
	Fence, chain link 7' high w/3-strand barbed wire top	25,600	lin.ft.	2.80	71,680
	Gate, 10' wide x 7' high chain link	7	each	110.00	770
	Piezometers	80	each	270.00	21,600
	Subtotal				$ 6,549,050

TABLE F-7 (Cont'd)

Salem Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	DAMS (Cont'd)				
	Contingencies				$ 981,950
	Subtotal for main dam				$ 7,531,000
	Operation and maintenance during construction, including contingencies				43,000
	TOTAL FOR DAMS				$ 7,574,000
07.	POWER PLANT				($53,372,000)
.1	Powerhouse				
	Penstock				
	Excavation, rock, tunnel	166,000	cu.yd.	16.00	$ 2,656,000
	Concrete, reinforced, tunnel	70,160	cu.yd.	38.00	2,666,080
	Steel, structural, tunnel lining	16,520,000	lb.	0.20	3,304,000
	Steel, structural, tunnel lining stiffeners	1,783,000	lb.	0.20	356,600
	Steel, structural, tunnel mine plates	2,705,000	lb.	0.20	541,000
	Steel, structural, tunnel mine plate supports	4,653,000	lb.	0.20	930,600
	Steel, concrete reinforcement, tunnel	1,892,000	lb.	0.15	283,800
	1-1/2" holes, drilled in rock for grouting	18,040	lin.ft.	4.50	81,180
	Grout tube (2" standard pipe)	10,900	lin.ft.	3.50	38,150
	Grout, cement	36,100	cu.ft.	5.00	180,500
	Subtotal for penstock				$11,037,910
	Channel connecting powerhouse to main dam reservoir				
	Excavation, common, channel	213,400	cu.yd.	0.45	96,030

TABLE F-7 (Cont'd)

Salem Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	POWER PLANT (Cont'd)				
	Excavation, rock channel	482,000	cu.yd.	4.00	$ 1,928,000
	Concrete, lightly reinforced, rock cut facing	10,080	cu.yd.	42.00	423,360
	Steel, concrete reinforcing, rock cut facing	504,000	lb.	0.15	75,600
	Anchors, rock cut facing each anchor consists of one #11 reinforcing bar 14'-8" long (wt. 78#) grouted into 4" dia. hole drilled 10' into rock	1,512	each	45.50	68,796
	Subtotal for channel				$ 2,591,786
	Reservoir outlet works				
	Excavation, common	6,300	cu.yd.	0.45	$ 2,835
	Excavation, rock, tunnel entrance	1,460	cu.yd.	4.00	5,840
	Excavation, rock, stilling basin	1,570	cu.yd.	3.50	5,495

TABLE F-7 (Cont'd)

Salem Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	POWER PLANT (Cont'd)				
	Excavation, rock tunnel	6,200	cu.yd.	20.00	$ 124,000
	Excavation, rock, control shaft	2,070	cu.yd.	18.00	37,260
	Backfill	870	cu.yd.	1.25	1,088
	Concrete, reinforced, tunnel entrance	35	cu.yd.	45.00	1,575
	Concrete, reinforced, stilling basin	320	cu.yd.	40.00	12,800
	Concrete, reinforced, tunnel lining	3,870	cu.yd.	50.00	193,500
	Concrete, reinforced, control shaft lining	840	cu.yd.	40.00	33,600
	Steel, structural, tunnel lining	406,600	lb.	0.20	81,320
	Steel, structural, tunnel lining stiffeners	42,700	lb.	0.20	8,540
	Steel, structural, tunnel mine plates	281,300	lb.	0.20	56,260
	Steel, structural, tunnel mine plates supports	267,500	lb.	0.20	53,500
	Steel, concrete reinforcing	186,800	lb.	0.15	28,020
	1-1/2" holes, drilled in rock for grouting	4,500	lin.ft.	4.50	20,250
	Grout tubes (2" standard pipe)	1,680	lin.ft.	3.50	5,880
	Grout, cement	9,000	cu.ft.	5.00	45,000
	Slide gate, 3.5' x 8' (197' head)	2	each	70,000.00	140,000
	Subtotal for reservoir outlet works				$ 856,763
	Structures and improvements				
	Hydraulic plant	sum	job		$13,000,000
	Transmission plant	sum	job		652,000
	Subtotal for structures and improvements				$13,652,000
	Subtotal for powerhouse				$28,138,459

TABLE F-7 (Cont'd)

Salem Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	POWER PLANT (Cont'd)				
.2	Turbines and generators				
	Hydraulic plant equipment	sum	job		$16,600,000
	Transmission plant equipment	sum	job		1,660,000
	Subtotal for turbines and generators				$18,260,000
	Subtotal for power plant				$46,398,459
	Contingencies				6,959,541
	Subtotal for power plant				$53,358,000
	Operation and maintenance during construction including contingencies				$ 14,000
	TOTAL FOR POWER PLANT				$53,372,000
08.	ROADS, RAILROADS, AND BRIDGES				($ 313,000)
	Roads				
	Road from storage area to powerhouse				
	Clearing and grubbing	9	acre	175.00	$ 1,575
	Stripping	8,000	cu.yd.	0.45	3,600
	Machine grading, class I	54	station	110.00	5,940
	Bituminous asphaltic concrete w/10" stone base	14,400	sq.yd.	6.90	99,360
	Subtotal				$ 110,475
	Road from powerhouse to right abutment area of dam				
	Clearing and grubbing	5	acre	175.00	875
	Stripping	4,400	cu.yd.	0.45	1,980
	Machine grading, class I	30	station	110.00	3,300
	Surface aggregate, gravel	2,300	ton	3.50	8,050
	Subtotal				$ 14,205

TABLE F-7 (Cont'd)

Salem Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	ROADS, RAILROADS AND BRIDGES (Cont'd)				
	Road from powerhouse to right abutment area of dam				
	Clearing and grubbing	13	acre	175.00	$ 2,275
	Stripping	21,100	cu.yd.	0.45	9,495
	Embankment and compaction	51,000	cu.yd.	0.75	38,250
	Machine grading, class I	46	station	110.00	5,060
	Surface aggregate, gravel	6,500	ton	3.50	22,750
	Subtotal				$ 77,830
	Subtotal for roads				$ 202,510
	Contingencies				30,690
	Subtotal for roads, exclusive of right-of-way				$ 233,200
	Right-of-way costs:				
	Storage area to powerhouse				800
	Powerhouse to right abutment area				800
	From right abutment area to left abutment area				1,200
	Subtotal for right-of-way costs				$ 2,800
	Total cost for roads				$ 236,000
	Railroads				
	Switch from main line to siding	sum	job		$ 3,300
	Single track siding	1,500	lin.ft.	11.50	17,250
	Clearing and grubbing, storage yard	50	acre	25.00	1,250
	Fence, chain link, 7' high w/3-strand barbed wire top, 6,000'	sum	job		17,100
	Gate, chain link, double 10' x 7'	4	each	110.00	440
	Subtotal for railroads				$ 39,340
	Contingencies				5,760
	Subtotal for railroads, exclusive of right-of-way				$ 45,100

TABLE F-7 (Cont'd)

Salem Reservoir, Hydropower, Plan II

Classification No.	Item	Quantity	Unit	Unit price	Total estimated cost
	ROADS, RAILROADS AND BRIDGES (Cont'd)				
	Right-of-way costs:				
	Railroad				$ 900
	Storage yard				25,000
	Subtotal for right-of-way costs				$ 25,900
	Total cost for railroads				$ 71,000
	Subtotal cost for roads, railroads and bridges				$ 307,000
	Operation and maintenance during construction, including contingencies				6,000
	TOTAL FOR ROADS, RAILROADS AND BRIDGES				$ 313,000
30.	ENGINEERING AND DESIGN				$ 3,760,000
31.	SUPERVISION AND ADMINISTRATION				$ 3,865,000
	TOTAL COST FOR SALEM, HYDROPOWER, PLAN II (July 1963)				$69,100,000

SECTION VI - ECONOMIC ANALYSIS

16. SUMMARY

The following table presents a summary of specific costs, cost per kilowatt installed capacity, and annual charges for each of the plans investigated.

TABLE F-8
Comparative cost per kilowatt

Item	Meramec Park			Pine Ford		Salem	
	Plan I	Plan II	Plan III	Plan I	Plan II	Plan I	Plan II
Load Factor							
Pump Back	-	25%	10%	25%	10%	25%	10%
Conventional	10%	-	10%	-	-	-	-
Plant Size (installed KW)							
Pump Back	-	120,000	300,000	160,000	400,000	100,000	250,000
Conventional	24,000	-	60,000	-	-	-	-
Specific 1st Cost (1)	$11,200,000	$51,100,000	$84,300,000	$60,200,000	$98,800,000	$38,700,000	$69,100,000
Cost per KW	$ 466	$ 426	$ 234	$ 376	$ 247	$ 387	$ 277
ANNUAL CHARGES							
1st Cost-Int. & Amort. (2)	$ 349,000	$ 1,622,000	$ 2,574,500	$ 1,838,500	$ 3,017,400	$ 1,181,900	$ 2,110,300
Operation							
Pump Energy (3)	-	739,000	696,400	932,900	932,900	640,600	636,000
Labor/Admin.	65,000	150,000	202,700	169,600	220,000	144,200	203,200
Maintenance	55,000	102,000	152,000	113,600	164,000	103,000	139,700
Major Replacements	17,000	50,000	120,900	61,800	110,500	42,400	89,200
Total Annual Charges - based on specific costs only (no joint cost share)	$ 486,000	$ 2,663,000	$ 3,746,500	$ 3,116,400	$ 4,444,800	$ 2,112,100	$ 3,178,400
ANNUAL BENEFITS							
Annual Net Charge/ installed KW (4)	$ 20.25	$ 18.29	$ 9.27	$ 15.78	$ 9.64	$ 17.06	$ 11.10

(1) First cost applicable to power only. Does not include any share of projects joint cost.
(2) Computed @ 3% for 100-year period. Was not based on applicable cost that would include "Interest during construction" (SCRB).
(3) Based on 2 mills per KWH in accordance with F.P.C. instructions.
(4) Reflects credit realized from sale of energy based on selling 2 KWH at 1.9 mills/KWH for each 3 KWH of pumping energy purchased at 2 mills/KWH.

17. JUSTIFICATION

On the basis of this analysis and review by the Southwestern Power Administration, it was concluded that installation of pumped-storage facilities at the reservoirs investigated is too costly to be justifiable

at this time. Therefore, no determination was made of the separable costs of storage allocations for power in the main reservoirs and benefit-cost ratios were not obtained. See letter dated 18 October 1963 from the Southwestern Power Administration, shown as EXHIBIT F-1. The Chicago Regional Office of the Federal Power Commission agrees that justification is lacking at this time on which to base a request for authorization of a power installation. However, it advises that there is a potential future power market at 10 percent load factor for the large installations possible in Plan III Meramec Park, Plan II Pine Ford, and Plan II Salem and recommends that these plans for hydropower be retained in the basin plan for future development. See letter dated 1 November 1963 from the Chicago Regional Office, shown as EXHIBIT F-2.

18. SUPPLEMENTARY DATA

a. Federal Power Commission study. The Chicago Regional Office of the Federal Power Commission submitted the attached supplement to this appendix, dated February 1964, in which it presents its conclusions with respect to utilization of the power output of three potential pumped storage projects in the Meramec River Basin. The Federal Power Commission states there will be a market as of 1980 in Power Supply Areas 15 and 40 for the output of pumped storage hydroelectric installations of 326,000 kilowatts at Salem 400,000 at Pine Ford, and 360,000 at Meramec Park. On the basis of separable costs only, the benefit-cost ratios for these three projects would be greater than unity. The Federal Power Commission concludes that the comprehensive basin plan should include these three hydroelectric projects. It does not suggest, however, that these power projects be authorized for early construction in view of the fact that their output will probably not be required prior to 1975-80.

b. Corps of Engineers review. The supplementary study of the Federal Power Commission has been reviewed by the Corps of Engineers. The Corps studied three power plans at Meramec Park and two power plans at Salem and Pine Ford. The Federal Power Commission has made further studies of Plan III Meramec Park and Plan I at Pine Ford and Salem. The Commission's analysis considered the specific costs only inasmuch as separable costs were not available. Annual benefits were based on a dependable capacity value of $23 per kilowatt per year. The following pertinent comments are made in regard to the three reservoirs.

(1) Meramec Park. The installed capacity, first cost, and other pertinent data are essentially the same as contained in the Corps study.

(2) Pine Ford. The Federal Power Commission provides for an installation of 400,000 kilowatts as compared to a 160,000-kilowatt installation by the Corps. The hilltop reservoir will be drawn down

15 feet, equivalent to 19,000 acre-feet, as compared to 5 feet, or 7,000 acre-feet, in the Corps study. Drawdown of 19,000 acre-feet from the main reservoir is equivalent to approximately 5-foot fluctuation, whereas drawdown of 7,000 acre-feet restricts fluctuations to 2 feet in the main reservoir. Drawdown proposed by the Federal Power Commission would not be compatible with recreational development at this reservoir.

(3) Salem. The Federal Power Commission analyzed an installation of 326,000 kilowatts, as compared to 100,000 kilowatts considered by the Corps. Drawdown in the hilltop reservoir would amount to 40 feet, or 18,000 acre-feet, as compared to 10-foot drawdown, or 5,000 acre-feet, in the Corps study. Drawdown of 18,000 acre-feet in the main reservoir would be equivalent to approximately 6-foot fluctuation, whereas drawdown of 5,000 acre-feet restricts fluctuations to 2 feet. Drawdown proposed by the Federal Power Commission would not be compatible with recreational development at this reservoir.

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
SOUTHWESTERN POWER ADMINISTRATION

POST OFFICE DRAWER 1619
TULSA 1, OKLAHOMA

October 18, 1963

District Engineer
U. S. Army Engineer District,
St. Louis
420 Locust Street
St. Louis, Missouri

Dear Sir:

This letter is in reply to your request made at the October 15, 1963, meeting of all Federal, State, and local public agencies participating in the comprehensive study of the Meramec River Basin. You requested comments by the various agencies as to project authorization and construction scheduling. Since hydropower is not to be a function of any project in the basin, the schedule of construction has no bearing on the plans of this Administration. Consequently, we have no recommendation.

We feel that your office has thoroughly studied the possibilities of inclusion of hydropower in the comprehensive plan. However, based on data which you have supplied us there is no power plan in which the power costs of the project can be recovered by marketing power under the current marketing experience of this Administration. We foresee no radical changes in either the cost of hydroelectric power installation or the price of electric power that would cause the construction of power facilities to later be justified at the projects studied.

As always, this Administration will be glad to assist you to the extent possible in development of the water resources of this basin.

Sincerely yours,

Douglas G. Wright

Douglas G. Wright
Administrator

cc:
Division Engineer
Lower Mississippi Valley
Division

EXHIBIT F-1

FEDERAL POWER COMMISSION

REGIONAL OFFICE

610 South Canal Street
Chicago, Ill. 60607

November 1, 1963

Colonel James B. Meanor, Jr.
District Engineer
U. S. Army Engineer District, St. Louis
420 Locust Street
St. Louis, Missouri 63102

Dear Colonel Meanor:

The following is in comment on the brochure entitled "Pertinent Data Meramec River Basin Study" distributed at the Inter-Agency Conference held in your office on October 15, 1963, and on the discussions during that Conference with respect to hydroelectric power. We are concerned that you apparently plan to omit any presentation of potential hydroelectric power projects from your report.

It was our view that the original objective of the Meramec River Basin Study was to present a comprehensive plan of development for that Basin which would give recognition to all feasible potential water and related land resources improvements. Accordingly, it is our conclusion that unless potential hydroelectric developments, principally pump-back, at the Meramec Park, Pine Ford, and Salem projects are included as parts of the Basin Plan, your report will have failed to achieve this original objective.

Our power studies have shown that there is a potential power market for 10-percent (or less) plant-factor generating installations for 250,000 kilowatts at Salem, 400,000 kilowatts at Pine Ford, and 360,000 kilowatts at Meramec Park. Conventional economic analyses indicated that on a basis of specific power costs (which in the case of the Meramec River Basin projects are also separable costs) the B/C ratios for these three projects would range from 1.35 to about 1.50. Although we have not received information from your office as to the allocated joint costs which might be chargeable to power at these three projects, it in no event appears that the B/C ratios would be reduced to less than unity by consideration of these charges.

Pursuant to the foregoing we recommend that you include in your comprehensive Basin report a presentation of the three hydroelectric projects suggested. We do not suggest that you recommend authorization of the construction of these projects; however, we believe the report should state that although presenting a favorable picture on the basis of conventional economic analyses, the power developments are not

EXHIBIT F-2

recommended for authorization by reason of the fact that the Southwestern Power Administration has stated they cannot dispose of the power output at the prices indicated.

At the meeting in your office on October 15 it is understood the SPA representative stated that his Agency could obtain pumped storage power in Arkansas at lower costs than those indicated for the Meramec River Basin. It is likely that there are higher heads in Arkansas and that the unit cost for pump-back hydroelectric power there would be less than in the Meramec Basin. However, it is our view that Meramec Basin power would be integrated with electric power resources in the Illinois-Missouri power pool (PSA's 15 and 40), and possibly also with those in the Kansas City area. There is some question that projects in Arkansas could compete with Meramec Basin projects in this market area due to the likely greater transmission costs required to properly integrate these more remote plants with the electric power supply in the market area considered.

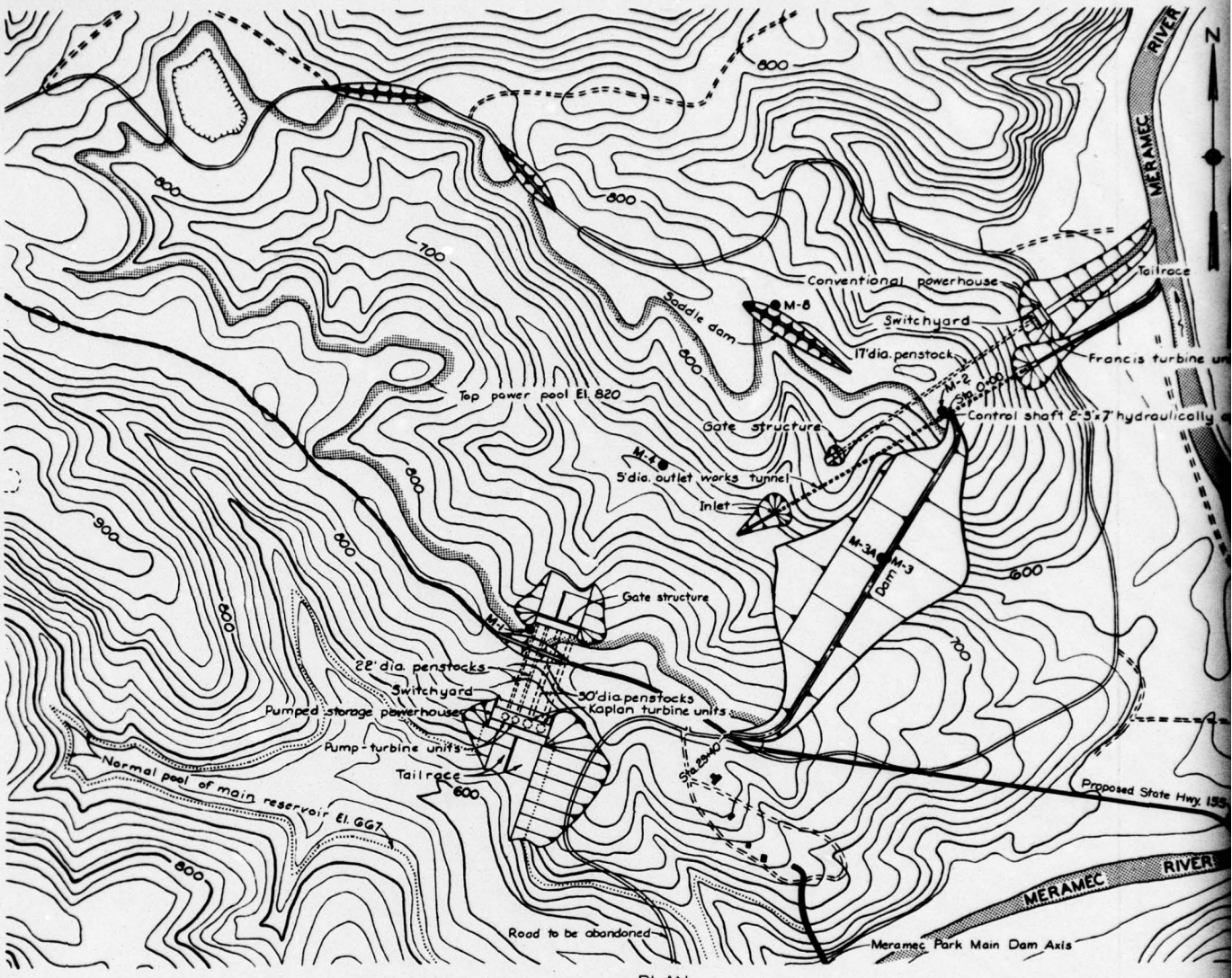
It is our understanding that we are to submit a Power Appendix for attachment to your Meramec River Basin report. It is our thought that this Appendix would present economic analyses for the power projects discussed above together with an analysis of the power market and an estimate of the future date or dates at which the power installations described could be best used to serve the power market's requirements.

If our views differ materially from yours, we would appreciate being informed. At present we plan to have a Power Appendix of the nature described above prepared for submission to your office in 100 copies early next January.

Sincerely yours,

Kenneth G. Tower
Regional Engineer

CORPS OF ENGINEERS



PLAN

SCALE IN FEET

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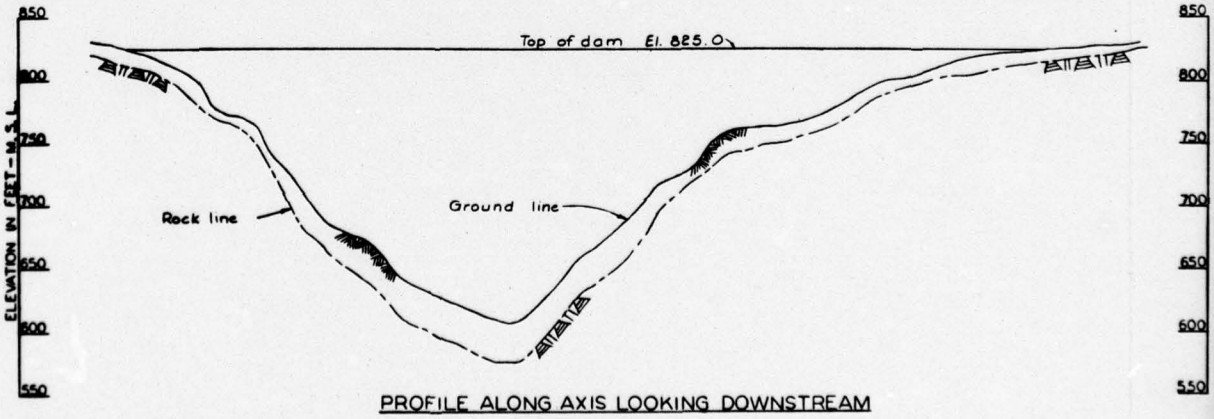
CONTOUR INTERVAL 20 FEET

BORING LEGEND

● = Machine Borings

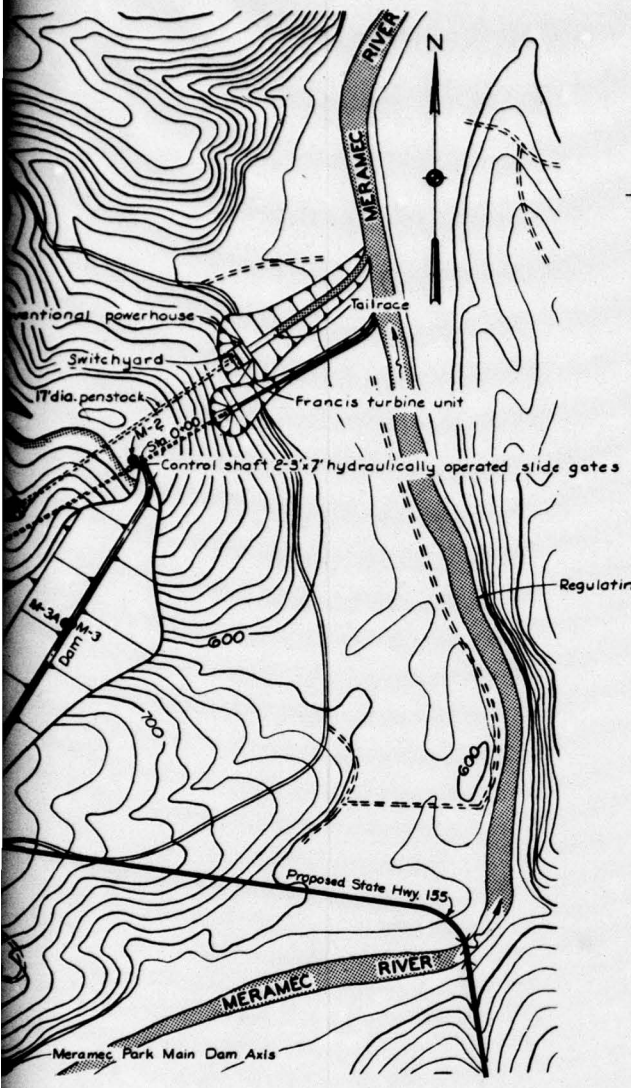


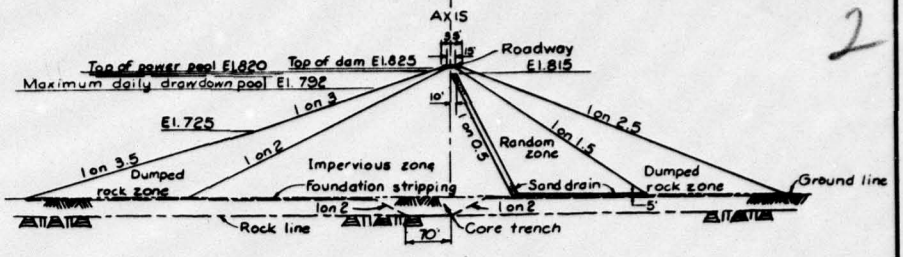
PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONTAL SCALE IN FEET

200 0 200 400

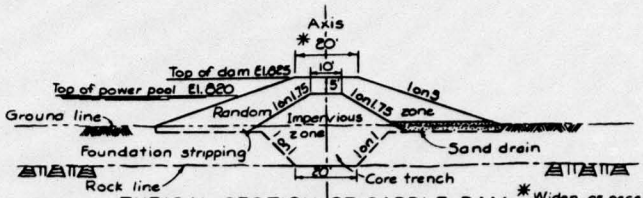
2





TYPICAL SECTION OF DAM

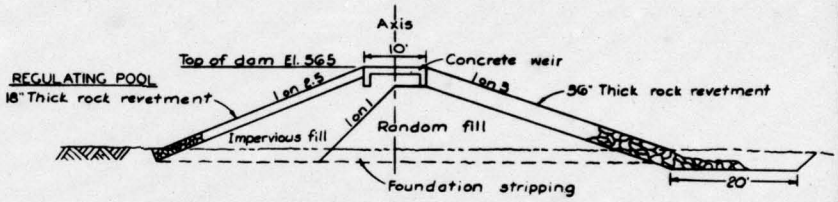
SCALE IN FEET



TYPICAL SECTION OF SADDLE DAM

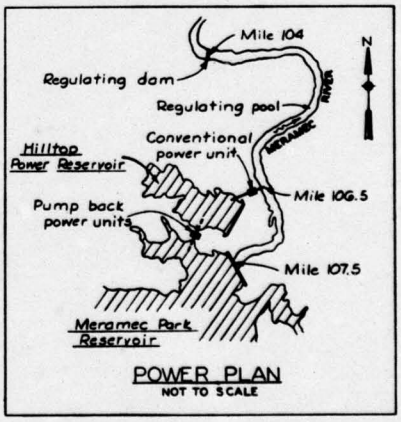
* Widen as necessary to accommodate Mo. Hwy. 155 as relocated along south rim of reservoir.

SCALE IN FEET

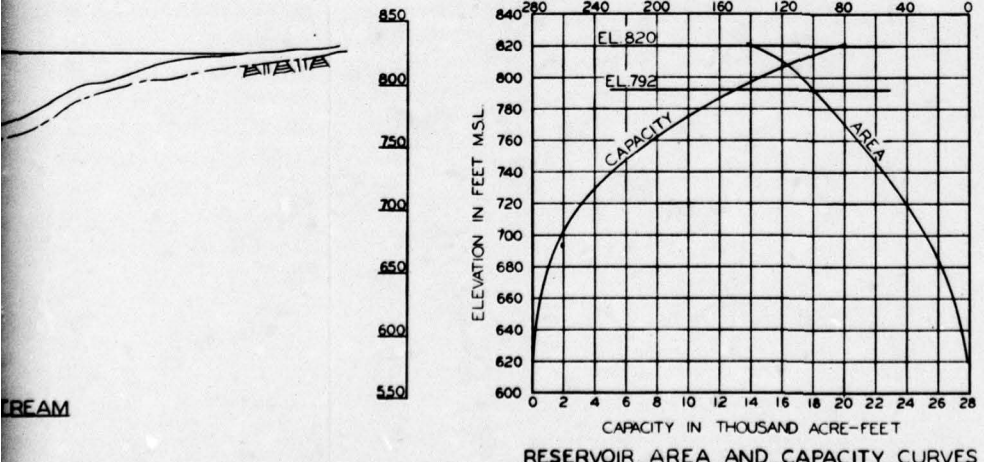


TYPICAL SECTION OF REGULATING DAM

SCALE IN FEET



POWER PLAN
NOT TO SCALE



RESERVOIR AREA AND CAPACITY CURVES

TREAM

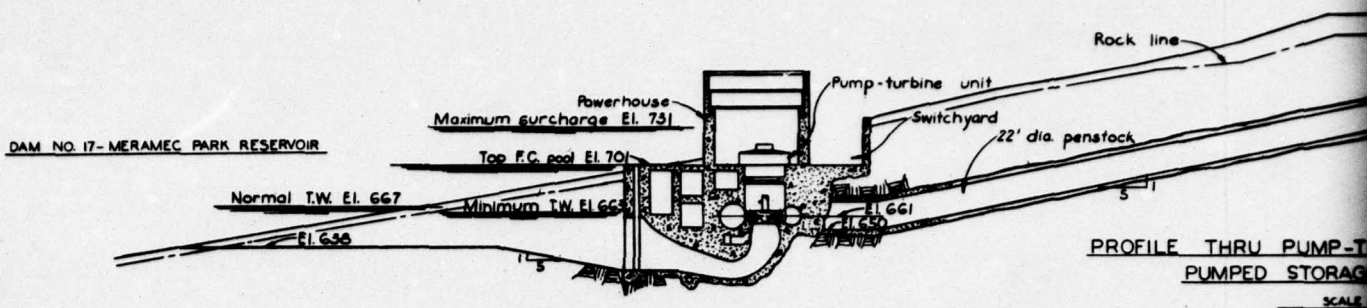
MERAMEC RIVER BASIN, MISSOURI
MERAMEC RIVER
MERAMEC PARK HILLTOP DAM
HYDROELECTRIC POWER FEATURES

IN 1 SHEET SHEET NO. 1

SCALE AS SHOWN

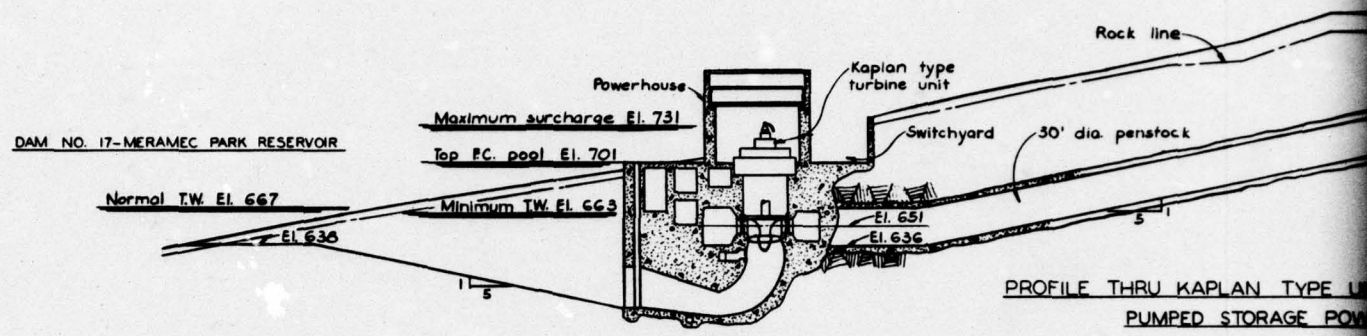
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE F-1



PROFILE THRU PUMP-T
PUMPED STORAG

SCALE
50 0



PROFILE THRU KAPLAN TYPE U
PUMPED STORAGE POW

SCALE IN FEET
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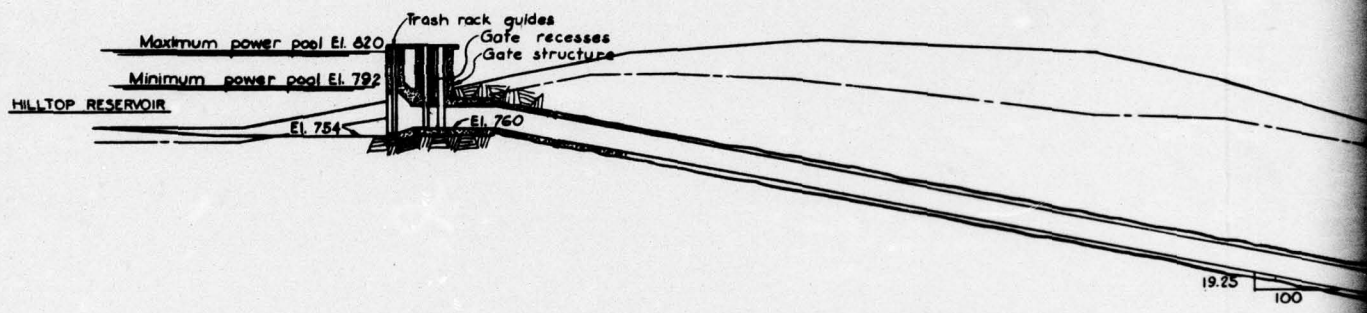

PROFILE THRU FRANCIS TYPE UNIT AND
CONVENTIONAL POWERHOUSE

SCALE IN FEET
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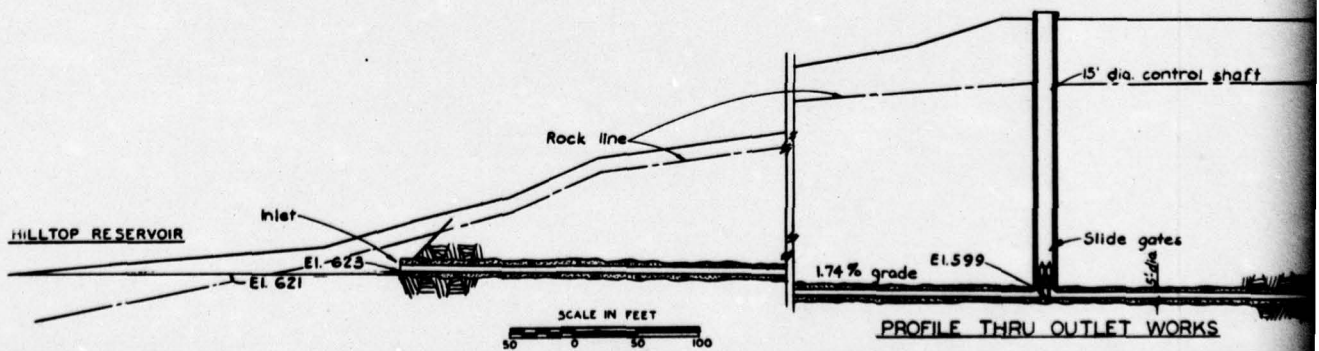

SCALE IN FEET
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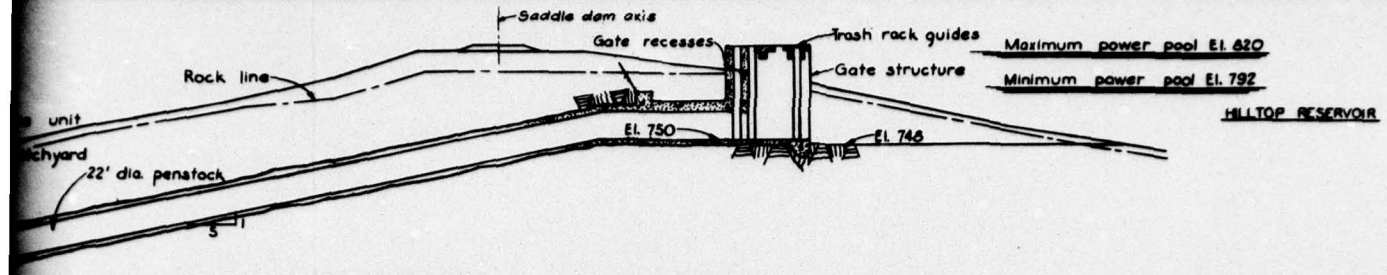
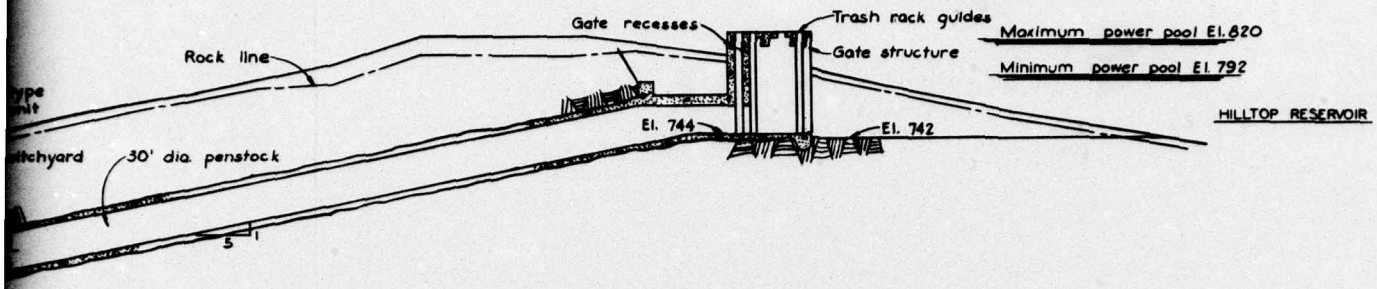
PROFILE THRU OUTLET WORKS

U. S. ARMY



PROFILE THRU PUMP-TURBINE UNIT AND PENSTOCK
PUMPED STORAGE POWERHOUSE

SCALE IN FEET
50 0 50 100



PROFILE THRU KAPLAN TYPE UNIT AND PENSTOCK
PUMPED STORAGE POWERHOUSE

SCALE IN FEET
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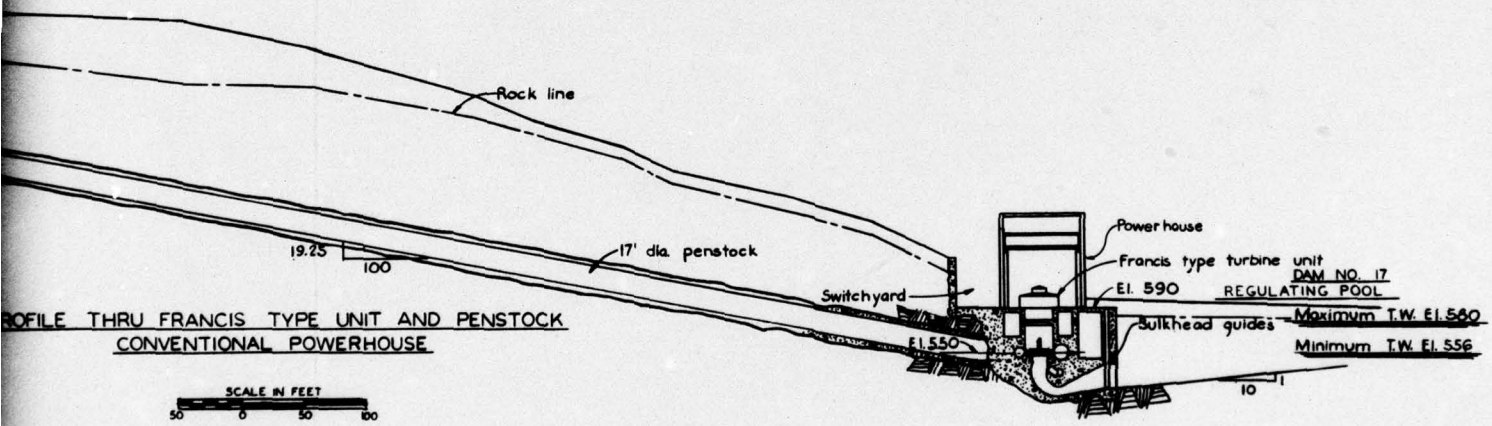
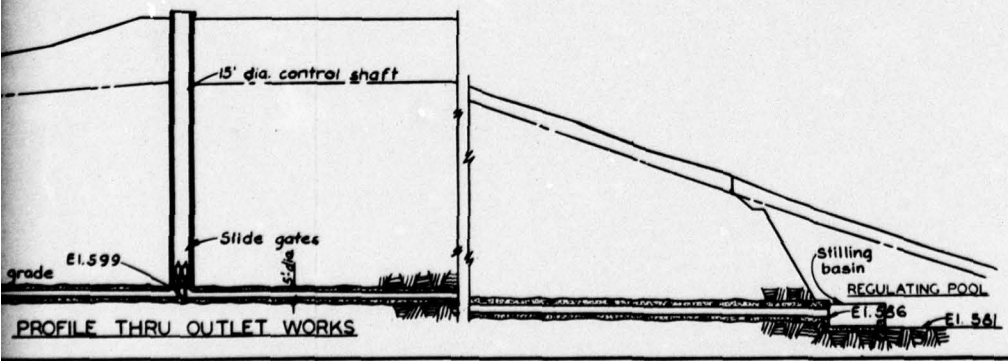


PROFILE THRU FRANCIS TYPE UNIT AND PENSTOCK
CONVENTIONAL POWERHOUSE

SCALE IN FEET
50 0 50 100

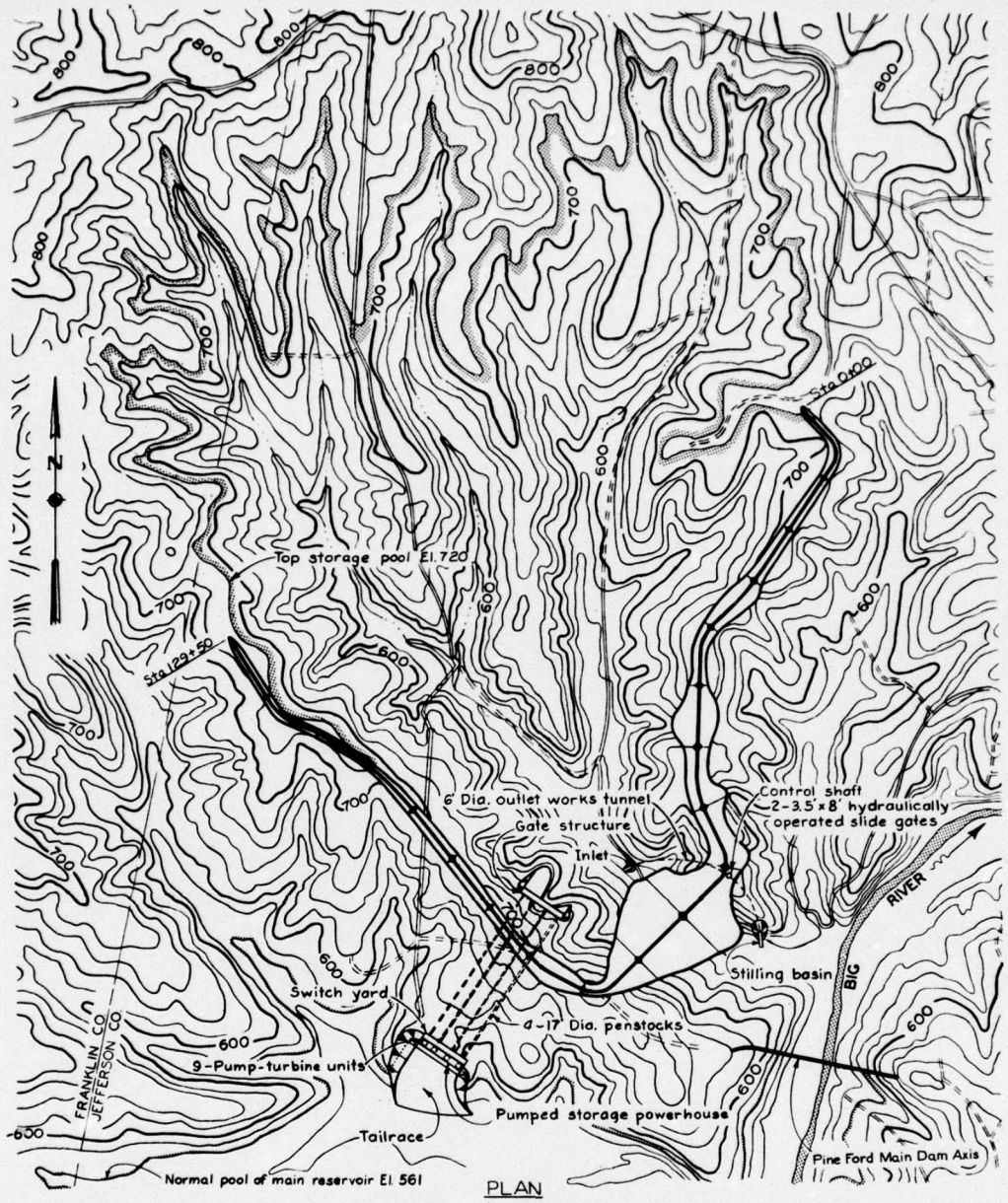


PROFILE THRU OUTLET WORKS

MERAMEC RIVER BASIN, MISSOURI
MERAMEC RIVER
MERAMEC PARK HILLTOP DAM
POWER FACILITIES

IN 1 SHEET SHEET NO. 1
SCALE AS SHOWN
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

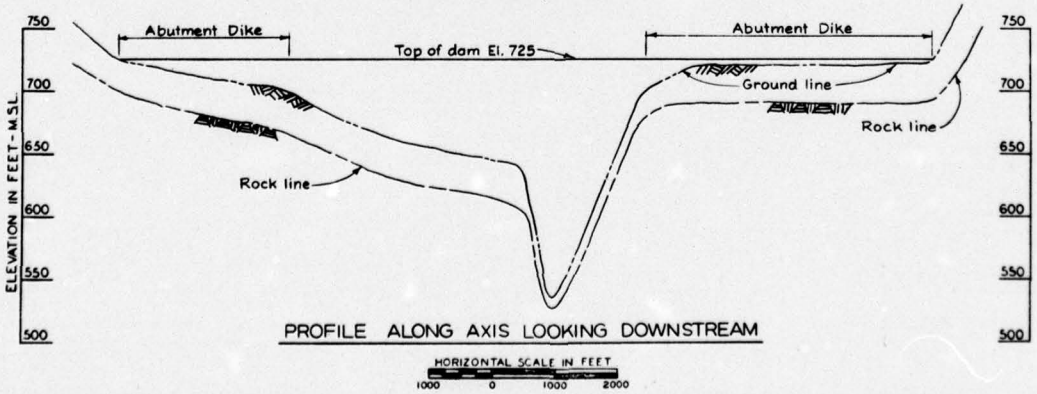
PLATE F-2



PLAN

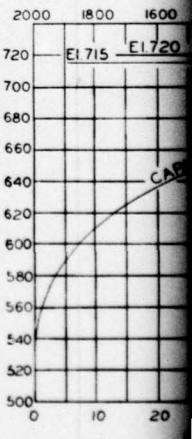
SCALE IN FEET
800 0 800 1600

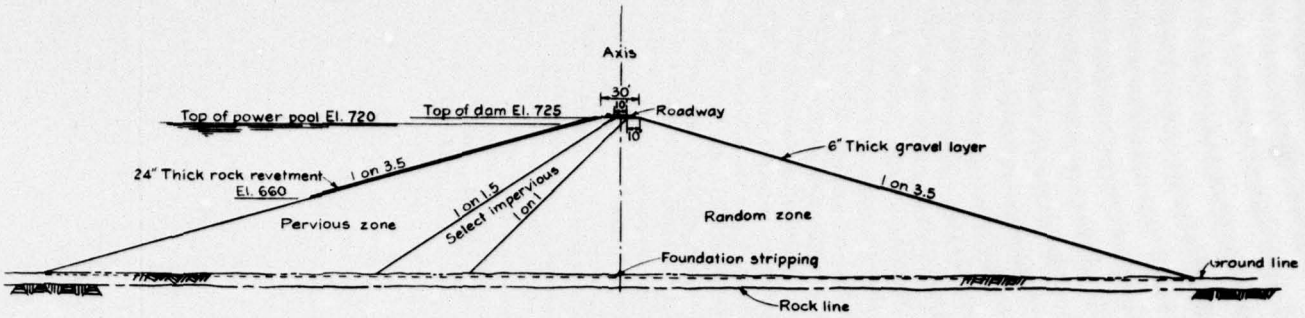
CONTOUR INTERVAL 20 FEET



PROFILE ALONG AXIS LOOKING DOWNSTREAM

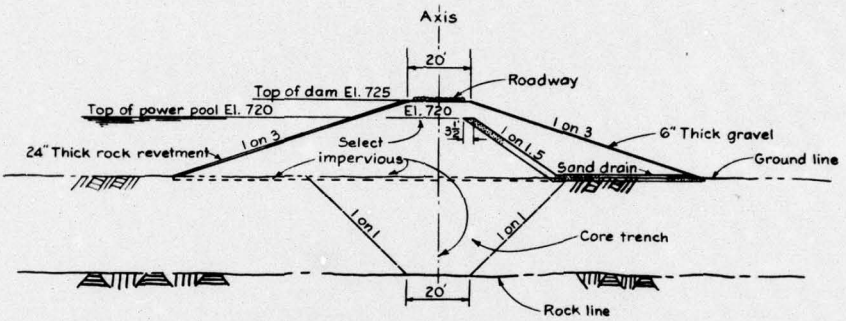
HORIZONTAL SCALE IN FEET
1000 0 1000 2000





TYPICAL SECTION OF DAM

SCALE IN FEET
50 0 50 100



TYPICAL SECTION ABUTMENT DIKE

SCALE IN FEET
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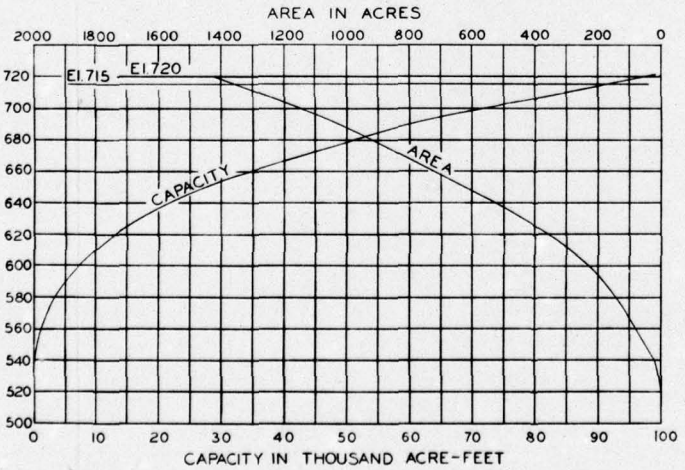


RESERVOIR AREA AND CAPACITY CURVES

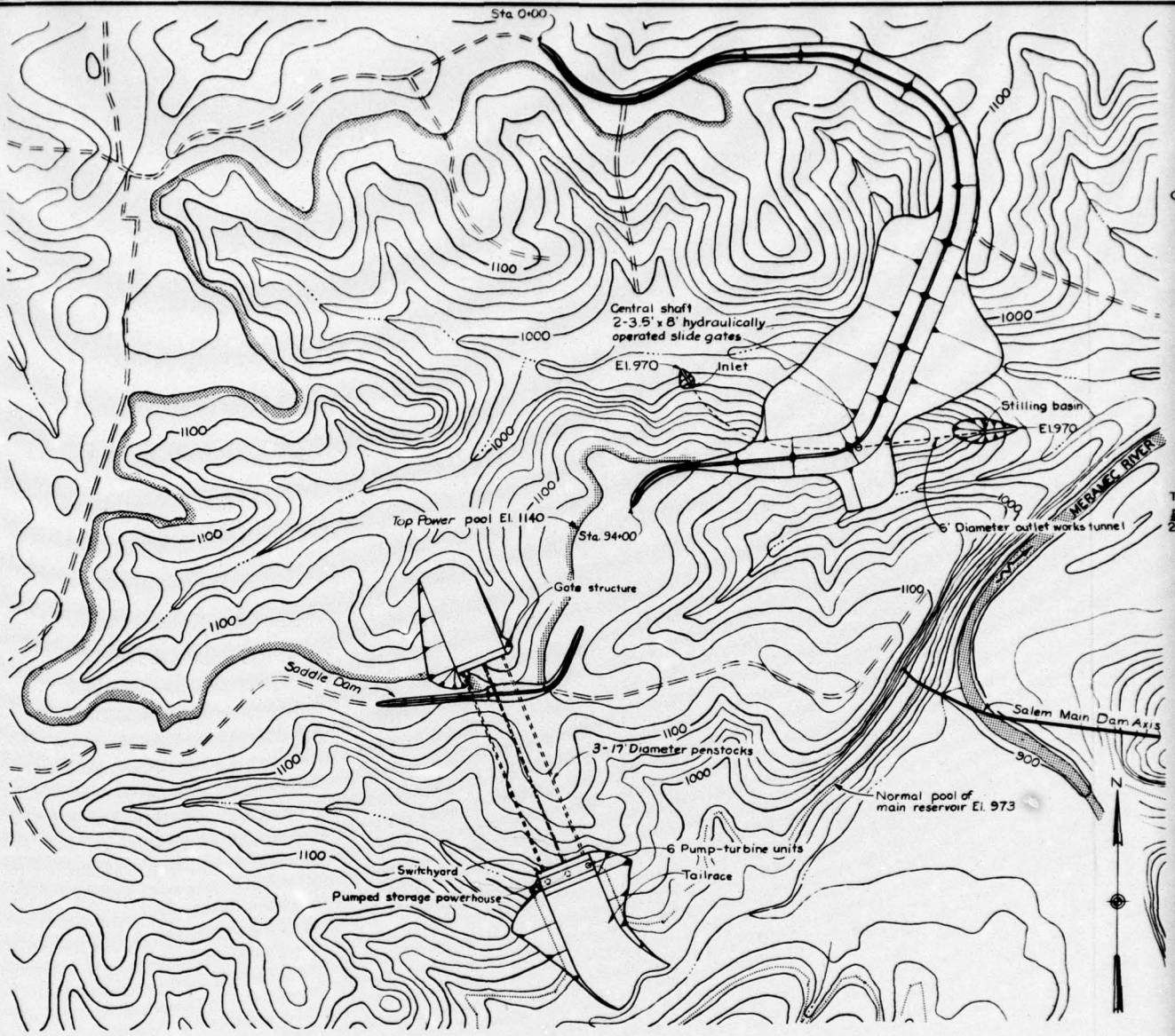
MERAMEC RIVER BASIN, MISSOURI
BIG RIVER
PINE FORD HILLTOP DAM
HYDROELECTRIC POWER FEATURES

IN 1 SHEET SHEET NO. 1

SCALE AS SHOWN

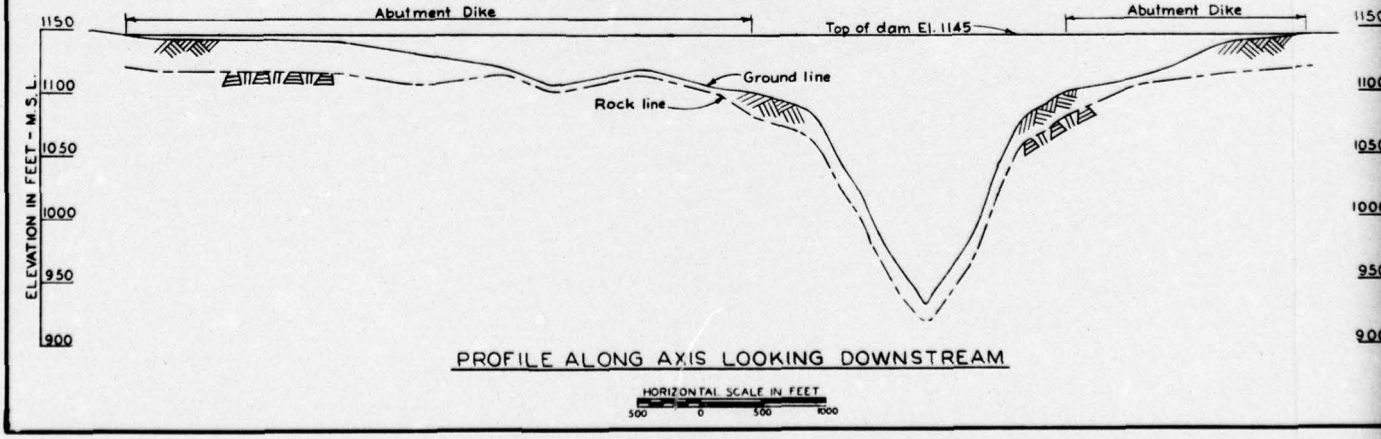
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

CORPS OF ENGINEERS



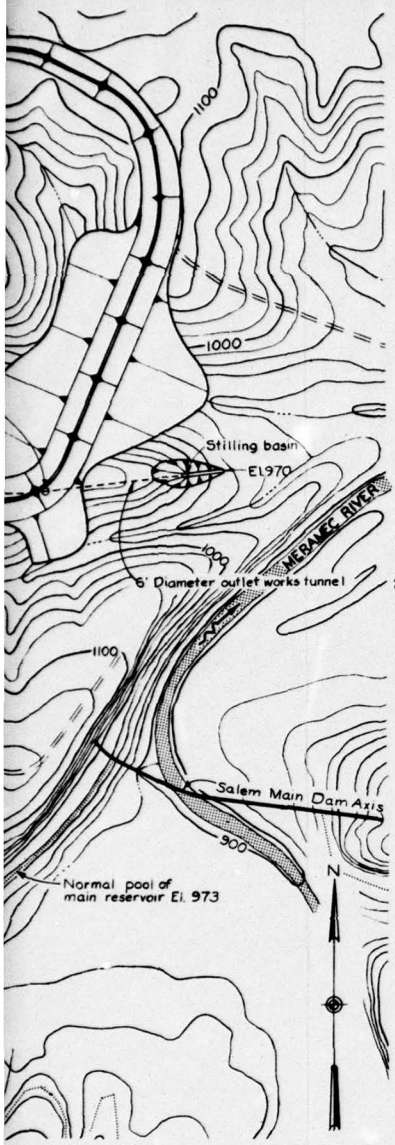
PLAN

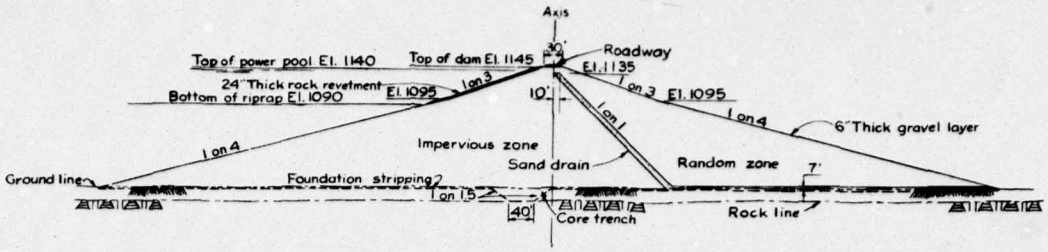
SCALE IN FEET
500 0 500 1000
CONTOUR INTERVAL 20 FFET



PROFILE ALONG AXIS LOOKING DOWNSTREAM

HORIZONTAL SCALE IN FEET
500 0 500 1000





TYPICAL SECTION OF DAM

SCALE IN FEET
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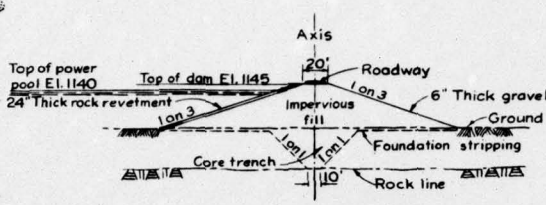

TYPICAL ABUTMENT SECTION

SCALE IN FEET
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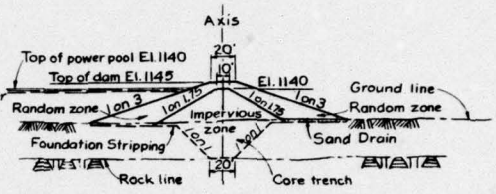
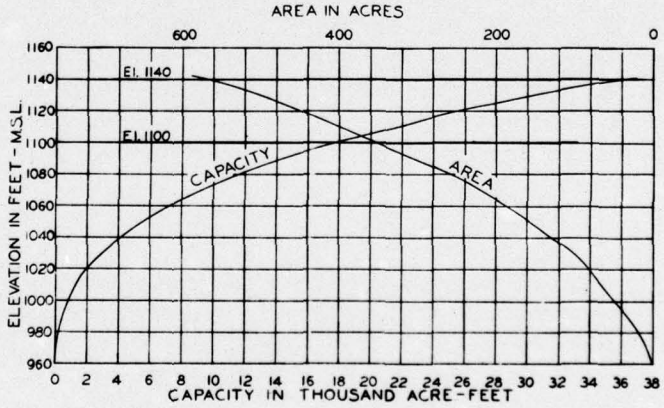
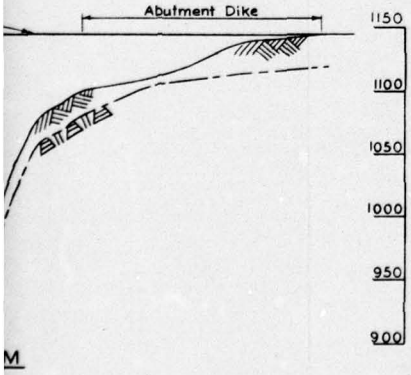


TYPICAL SECTION OF SADDLE DAM

SCALE IN FEET
50 0 50 100



RESERVOIR AREA AND CAPACITY CURVES



M

MERAMEC RIVER BASIN, MISSOURI
MERAMEC RIVER
SALEM HILLTOP DAM
HYDROELECTRIC POWER FEATURES

IN 1 SHEET SHEET NO. 1

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE F-4

VOLUME V

Supplement to Appendix F
HYDROPOWER

Table of Contents

Subject	Page
1. Introduction	F_S-1
2. Power Marketing Area	F_S-2
3. Power Requirements	F_S-3
4. Utilization of Power Potential - Meramec Basin	F_S-4
5. Economic Analyses	F_S-6
6. Summary	F_S-11

Tables

Summary Data and Economic Analyses
Pumped Storage Hydro

1. Meramec Park Project	F_S-8
2. Salem Project	F_S-9
3. Pine Ford Project	F_S-10

Plates	Following Page
F_S-1 Map - Power Supply Areas 15 and 40	F_S-11
F_S-2 Daily Load Curve for Week of Annual Peak, PSA 15 and 40	F_S-11
F_S-3 Power Duration Curve for Week of Annual Peak, PSA 15 and 40	F_S-11

Federal Power Commission
Chicago Regional Office
February - 1964

APPENDIX F - SUPPLEMENT

HYDROPOWER

1. INTRODUCTION

This Supplement to Appendix F, designated as "F_S", presents the conclusions of the Chicago Regional Office of the Federal Power Commission with respect to the utilization of the power output of three potential pumped storage projects in the Meramec River Basin, totaling approximately one million kilowatts of dependable capacity, in view of the future power requirements of the logical marketing area which would be served by these projects. In our analyses of power supply, cognizance has been taken of other major hydroelectric plants having a total of 700,000 kilowatts of dependable capacity which will be serving the marketing area. These are the existing Keokuk, Bagnell, and Taum Sauk projects of the Union Electric Company and the Federal hydroelectric plants proposed for the Stockton, Kaysinger Bluff, and Joanna multiple-purpose projects. Keokuk is run-of-river, Bagnell a conventional storage project. Both have been in service for a number of years. Taum Sauk is a high-head pumped storage project which was placed in service in 1963. The Joanna project combines conventional and pumped storage. All of the Federal projects, excepting those three proposed herein for the Meramec Basin, are either under construction or are authorized for construction.

The basic data utilized in the preparation of this Supplement was obtained largely from Power System Statements submitted annually to the

Federal Power Commission by the electric utilities, the FPC National Power Survey Report currently in preparation, and Corps of Engineer' reports.

2. POWER MARKETING AREA

The dependable peaking capacity potential of about one million kilowatts in the three Meramec Basin projects required consideration be given to the power supply area or areas most likely to be served, rather than to be confined to the limited service area of a single marketing entity. Although two of the three proposed hydros are a short distance outside Power Supply Area 15 they are near the metropolitan area of St. Louis which straddles the Mississippi River to include a part of PSA 40 in Illinois. All three are closer to St. Louis than the Union Electric Company's Taum Sauk project. Accordingly, it has been concluded that Power Supply Areas 15 and 40 constitute a logical market for Meramec River power. Plate F_S-1 shows the location of these power supply areas and the hydroelectric projects considered in the study.

In general, Power Supply Area 15 lies north of a diagonal line drawn from the northwest to the southeast corners of the State of Missouri; Power Supply Area 40 covers roughly the southern half of Illinois.

The population forecasted for 1970 and 1980 is as follows:

	Population (1000)	Estimated Population (1000)	
	1960	1970	1980
PSA 15	2,308	2,564	2,850
PSA 40	2,676	2,932	3,214
Total	4,984	5,496	6,064

Statistics show that the urban population in the above areas is 75-80 percent of the total for PSA 15 and 50 percent of the total in PSA 40.

The power loads and supply requirements in 1960, 1970, and 1980 are shown at major load centers in PSA 15 and 40 in the following table.

		1960		1970		1980	
PSA	Centers	Load	Supply	Load	Supply	Load	Supply
		- - - - - - - - -		1000 kw		- - - - - - - - -	
15	Marcelline, Mo.	336	-	630	-	1,150	-
	St. Louis, Mo.	1,650	2,100	3,070	3,200	5,650	5,200
	Taum Sauk, Mo.	-	-	-	500	-	1,500
	Subtotals	1,986	2,100	3,700	3,700	6,800	6,700
40	Atomic Energy Commission	744	-	750	-	750	-
	Belleville, Ill.	209	-	435	-	800	-
	Champaign, Ill.	373	-	465	-	1,500	-
	Joppa, Ill.	288	1,000	590	1,500	1,150	2,100
	Peoria, Ill.	402	2,700	830	3,600	1,600	6,700
	Quincy, Ill.	236	-	485	-	950	-
	Springfield, Ill.	284	-	585	1,700	1,150	3,000
	Subtotals	2,536	3,700	4,440	6,800	7,900	11,800
Total 15 & 40		4,522	5,800	8,140	10,500	14,700	18,500

3. POWER REQUIREMENTS

The FPC National Power Survey investigations of the power requirements for PSAs 15 and 40 indicate that power loads, in general, double approximately each decade. The historical annual energy and the peak requirements including the month of the system peak for 1950 and 1960 and similar information forecasted for 1970 and 1980 are as follows for Power Supply Areas 15 and 40.

	PSA - 15			PSA - 40		
	Energy 10^6 kwh	MW	Mo.	Energy 10^6 kwh	MW	Mo.
1950	5,261	951	12	4,437	914	12
1960	9,779	1,986	9	16,048	2,536	9
1970	18,900	3,700	8	26,400	4,500	12
1980	35,300	6,800	8	45,500	7,900	8

The month of the system peak for 1980 has been forecast in the National Power Survey investigations to be August for both power supply areas. The August 1980 power requirements according to NPS are, energy 7.650 billion kilowatt-hours, peak load 14,700 megawatts. Allowing for diversity, the peak load demand is estimated to be 14,631 megawatts for the combined areas. The base load is estimated to be 42 percent of the peak or 6,160 megawatts.

To evaluate properly the utilization of the power potential of the three potential Meramec Basin pumped storage projects, it is necessary to consider the peak daily and weekly load requirements of the service area in 1980.

4. UTILIZATION OF POWER POTENTIAL - MERAMEC BASIN

The three pumped storage projects in the Meramec River Basin which appear to have merit are, as previously stated, Meramec Park, Salem and Pine Ford with total dependable capacity for serving peak load of approximately one million kilowatts. Each of the three projects would be designed principally to circulate water between a hilltop pond and the conservation or joint use pool of the main reservoir. However, the proposed

Meramec Park project would include sufficient storage in the hilltop reservoir to contain the daily minimum regulated flow which would be discharged into the Meramec River through a second downstream powerplant. The usable storages in the hilltop ponds are limited to a daily cycle of operation for design plant factors of 10 percent for Meramec Park and 25 percent for both Salem and Pine Ford projects. Since carryover storage is not available when operating at these plant factors, it is essential that the ability of these plants to supply load must be determined from a consideration of the daily load at the time of the system peak. The annual system peak for 1980 in Power Supply Areas 15 and 40 has been forecast by the National Power Survey to be in August. Daily load data by hours for the week of the annual peak in August 1980 were obtained by extrapolating historical daily load data for the second week in August 1960. The daily load curve for the week of the system peak as shown on Plate F_S-2 includes one of the positions each of the Meramec hydros could take in serving the indicated loads. In addition, the potential of the Taum Sauk, Keokuk, Bagnell, Stockton, Kaysinger Bluff and Joanna hydros have also been placed on the weekly curve. During the week of the system peak, the peak demand was estimated to be 14,631.0 megawatts, the energy requirements 1577.0 mkwh, and the load factor 64.2. On the day of the system peak, the energy requirements were 253.5 mkwh, the load factor 72.2 percent, and the base load 45.8 percent of the maximum demand or 6,700 megawatts. The summary of the week's hydro operations for the peak day and week are summarized in the following table.

Hydro Project	Dependable Capacity-MW	Energy and Load Factor			
		Peak Day		Week of Peak	
		Mwh	L.F.%	Mwh	L.F.%
Meramec Park	288.0	840.0	12.5	1,440.0	3.0
Salem	292.0	1,840.0	26.3	3,100.0	6.3
Pine Ford	380.0	2,280.0	25.0	5,320.0	8.3
Taum Sauk	350.0	2,800.0	33.0	8,050.0	13.7
Joanna	54.0	460.0	35.0	1,460.0	16.2
Stockton and Kaysinger Bluff	92.8	835.0	37.5	2,600.0	16.7
Keokuk and Bagnell	210.0	2,100.0	43.5	6,800.0	22.1

The duration curve for the peak week is shown on Plate F_S-3. For closer study the upper 30 percent of the duration curve was plotted on a larger scale showing the position the hydro plants could take in serving the load during the week of the system peak.

5. ECONOMIC ANALYSES

In Section 4 it has been shown that the output of the Meramec Park, Salem, and Pine Ford pumped storage hydros can be effectively utilized on the 1980 load for Power Supply Areas 15 and 40. In the economic analyses, it was assumed that the hydroelectric plants and related transmission facilities were constructed by the Federal Government. The analyses considered the separable capital costs of the hydroelectric projects only, inasmuch as information on the allocation of joint costs to the hydroelectric projects was not available. The estimated capital costs of the hydroelectric projects are as follows:

		Capital Costs (Separable)
Meramec Park	360 MW	$ 84,300,000
Salem	326 MW	81,970,000
Pine Ford	400 MW	124,475,000

Detailed breakdowns of the above costs are shown in Tables 1, 2 and 3, respectively.

Annual costs are based on fixed costs of 4.487 percent, which assumes a 50-year life of power facilities with amortization at a 3% interest rate, interim replacements at 0.400% and costs in lieu of insurance at 0.200%. Operation and maintenance costs reflect the assumption that the plants would be automated. The cost of energy for pumping has been estimated at 2.0 mills per kilowatt-hour and the annual energy requirements for pumping at 1.5 times the annual generation. For the purpose of the economic analyses, annual generation was assumed to be 52 times that of the peak week. Power values are based on the costs of power produced by the most likely alternative source, which is assumed to be a privately-financed steam plant of the size and type typical of those currently planned for Power Supply Areas 15 and 40. Capacity and energy values on this basis are as follows:

Capacity - $23.00 per kilowatt per year

Energy - 1.9 Mills per kilowatt-hour

Economic analyses of the three proposed hydroelectric projects are detailed in Tables 1, 2, and 3 immediately following. These three tables are summarized as follows:

	$1000		
	Meramec Park	Salem	Pine Ford
Annual Cost	$4,652.0	$4,717.0	$7,008.0
Annual Benefits	6,767.0	7,022.0	9,265.0
Remaining Benefits	2,115.0	2,305.0	2,257.0
B/C	1.45	1.49	1.32

TABLE 1

Summary Data and Economic Analysis
Meramec Park Pumped Storage Project

Hilltop Reservoir - Operation Limits - Elevations 820-792
Storage - 6000 acre-feet or 700,000 kwh Energy
To river 700 acre-feet or 140,000 kwh Energy
Main Reservoir - Joint Use Pool - Elevations 667.0-663.0
Net Storage - 50,000 acre-feet
Head-Average Net-Pumped Storage - 138.0 ft.; Conventional to river - 240.0 ft.

Installation, kw-Pumped Storage - 300,000; Dependable Capacity - 228,000
Conventional - 60,000; " " - 60,000
Installation based on utilization of hilltop reservoir storage at 10 percent daily use factor.
Energy, kwh - Peak Day - 840,000; Peak Week - 1,440,000
Annual, kwh - Generation - 75,000,000; Pumping - 112,000,000

Capital Costs (Separable - Corps of Engineers' estimate)		
Lands	$ 46,000	
Reservoir Clearing	69,000	
Dam and Saddle Dam	19,900,000	
Regulating Dam	100,000	
Powerplant	55,600,000*	
Access Roads	244,000	
Engineering and Design	4,160,000	
Supervision and Administration	4,181,000	
Total		$84,300,000
Annual Cost		
Fixed Cost-4.487% (50 yr.@3.0%)	$ 3,780,000	
O & M & Adm.	648,000	
Subtotal	4,428,000	
Energy for pumping		
112 Mkwh @ 2 Mills	224,000	
Total Annual Cost		$ 4,652,000
Annual Benefits (At site)		
Capacity - 288 MW @ $23/kw	$ 6,624,000	
Energy - 75 Mkwh @ 1.9 Mills	143,000	
Total Annual Benefits		$ 6,767,000
Benefit to Cost Ratio	1.45	

*CRO Estimate $48,550,000

TABLE 2

Summary Data and Economic Analysis
Salem Pumped Storage Project

Hilltop Reservoir - Operation Limits - Elevations 1140.0-1100
Storage - 18,000 acre-feet or 1,840,000 kwh Energy
Main Reservoir - Joint Use Pool - Elevations 995.0-928.0
Net Storage - 125,200 acre-feet
Head - Average Net - 124.0 ft.

Installation, kw - 326,000; Dependable Capacity - 292,000
Installation based on utilization of usable storage in hilltop reservoir at 25 percent daily use factor.
Energy, kwh - Peak Day - 1,840,000; Peak Week - 3,100,000
Annual, kwh - Generation - 161,000,000; Pumping - 242,000,000

Capital Costs (Separable - Corps of Engineers' estimate)		
Lands	$ 80,000	
Reservoir Clearing	136,000	
Dam, including saddle dams	7,574,000	
Powerplant	65,436,000*	
Access Roads	313,000	
Engineering and Design	4,150,000	
Supervision and Administration	4,281,000	
Total		$81,970,000
Annual Cost		
Fixed Cost-4.487%(50yr.@3.0%)	$ 3,680,000	
O & M & Adm.	553,000	
Subtotal	4,233,000	
Energy for pumping 242 Mkwh @ 2 Mills	484,000	
Total Annual Cost		$ 4,717,000
Annual Benefits (At site)		
Capacity - 292 MW @ $23/kw	$ 6,716,000	
Energy - 161 Mkwh @ 1.9 Mills	306,000	
Total Annual Benefits		$ 7,022,000
Benefit to Cost Ratio	1.49	

*CRO Estimate $62,200,000

TABLE 3

Summary Data and Economic Analysis
Pine Ford Pumped Storage Project

Hilltop Reservoir - Operation Limits - Elevations 720.0-705.0
Storage 19,000 acre-feet or 2,310,000 kwh Energy
Main Reservoir - Joint Use Pool - Elevations 561.0-531.0
Net Storage - 76,300 acre-feet
Head - Average Net - 157.0 ft.

Installation, kw - 400,000; Dependable Capacity - 380,000
Installation based on utilization of usable storage in hilltop reservoir at 25 percent daily use factor.
Energy, kwh - Peak Day - 2,310,000; Peak Week - 5,320,000
Annual, kwh - Generation - 276,000,000; Pumping - 415,000,000

Capital Costs (Separable - Corps of Engineers' estimate, except as noted)		
Lands	$ 112,000	
Relocation	180,000	
Reservoir Clearing	345,000	
Dam, including saddle dams	13,213,000	
Powerplant	97,500,000	(CRO estimate)
Access Roads	725,000	
Engineering and Design	5,800,000	
Supervision and Administration	6,600,000	
Total		$124,475,000

Annual Cost		
Fixed Cost-4.487%(50 yr.@3.0%)	$ 5,530,000	
O & M & Adm.	648,000	
Subtotal	6,178,000	
Energy for pumping 415 Mkwh @ 2 Mills	830,000	
Total Annual Cost		$ 7,008,000

Annual Benefits (At site)		
Capacity - 380 MW @ $23/kw	$ 8,740,000	
Energy - 276 Mkwh @ 1.9 Mills	525,000	
Total Annual Benefits		$ 9,265,000

Benefit to Cost Ratio 1.32

6. SUMMARY

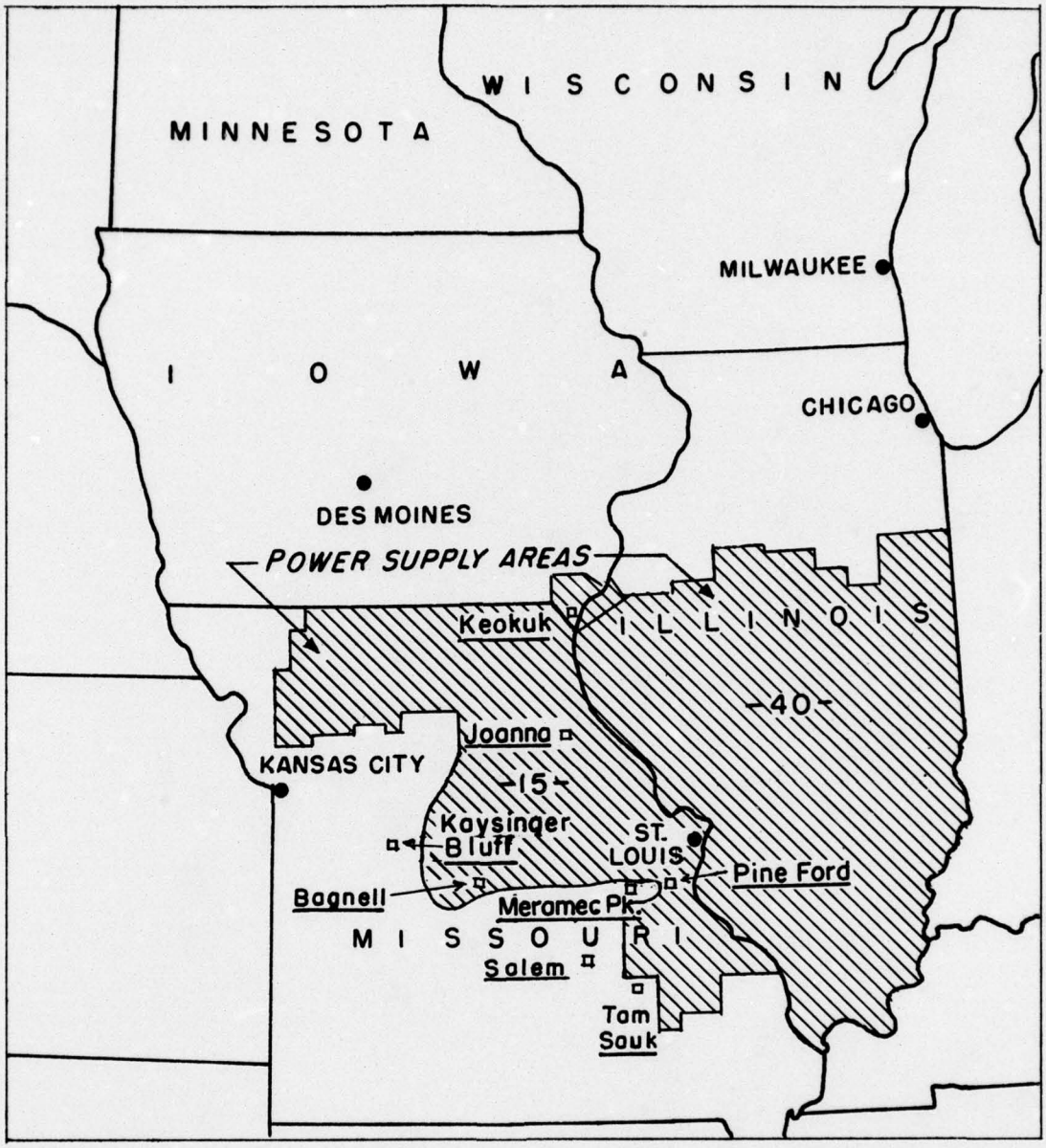
The power studies have shown that there will be a market as of 1980 in Power Supply Areas 15 and 40 for the output of pumped storage hydroelectric installations of 326,000 kilowatts at Salem, 400,000 kilowatts at Pine Ford, and 360,000 kilowatts at Meramec Park.

Conventional economic analyses indicated that on the basis of separable power costs the B/C ratios ror these three projects would range from about 1.3 to 1.5. Although the hydroelectric plant costs used in the economic analyses did not include allocated joint costs, in no event would the B/C ratios be reduced to less than unity by consideration of these charges.

It is apparent in appended Plates F_S-2 and F_S-3 that the three projects' power installations could have been utilized higher on the peak load thus, (1) requiring less energy to be generated, (2) permitting increased capacity with the same energy, or (3) suggesting they might be used on a somewhat lesser peak load at an earlier date or in a smaller marketing area at the same date. Generally speaking, it is believed that the analysis of the utilization of the projects' outputs to meet marketing requirements is somewhat conservative.

Pursuant to the foregoing it is believed that the comprehensive Basin plan should include the three hydroelectric projects proposed. It is not suggested that these power projects be authorized for early construction in view of the fact that their output will probably not be required to meet loads prior to 1975-80.

GPO 807-746-1

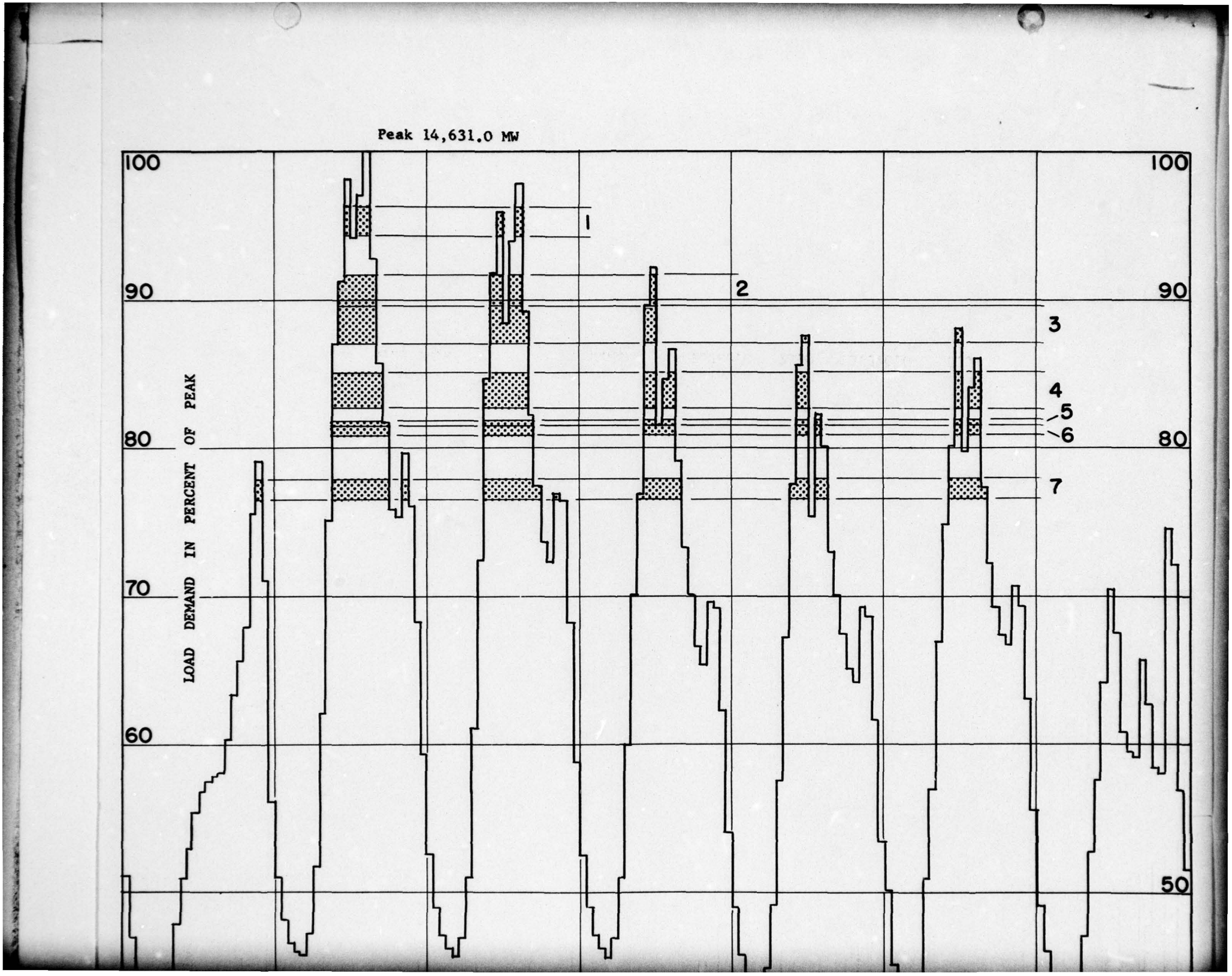


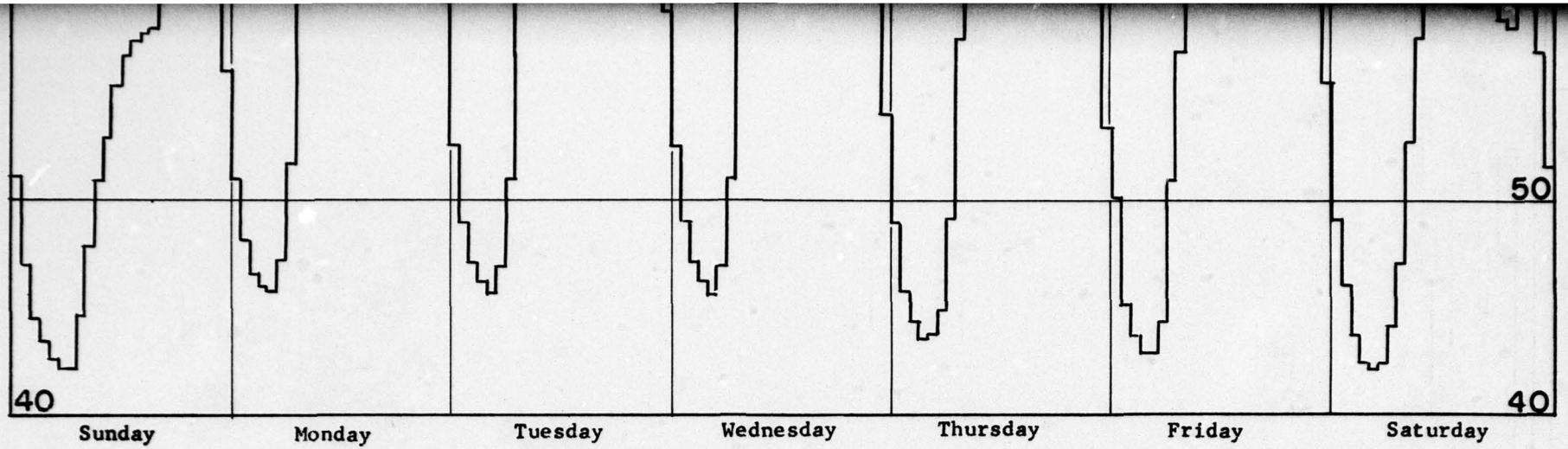
MERAMEC RIVER BASIN STUDIES

HYDROELECTRIC PROJECTS
AND
POWER MARKETING AREA
SERVED

FEDERAL POWER COMMISSION
CHICAGO REGIONAL OFFICE
FEBRUARY 1964

Plate FS-1


Peak 14,631.0 MW
100
90
80
70
60
50
LOAD DEMAND IN PERCENT OF PEAK
1
2
3
4
5
6
7



	Hydro Project	Dependable Capacity-MW	Energy and Load Factor: Peak Day MWH	Peak Day L.F.%	Week of Peak MWH	Week of Peak L.F.%
1.	Meramec Park	288.0	840.0	12.5	1,440.0	3.0
2.	Salem	292.0	1,840.0	26.3	3,100.0	6.3
3.	Pine Ford	380.0	2,280.0	25.0	5,320.0	8.3
4.	Taum Sauk	350.0	2,800.0	33.0	8,050.0	13.7
5.	Joanna	54.0	460.0	35.0	1,460.0	16.2
6.	Stockton and Kaysinger Bluff	92.8	835.0	37.5	2,600.0	16.7
7.	Keokuk and Bagnell	210.0	2,100.0	43.5	7,800.0	22.1

Week of Annual Peak
Peak Demand - 14,631.0 MW
Energy Required - 1,577.0 MKWH
Load Factor for Week - 64.2%

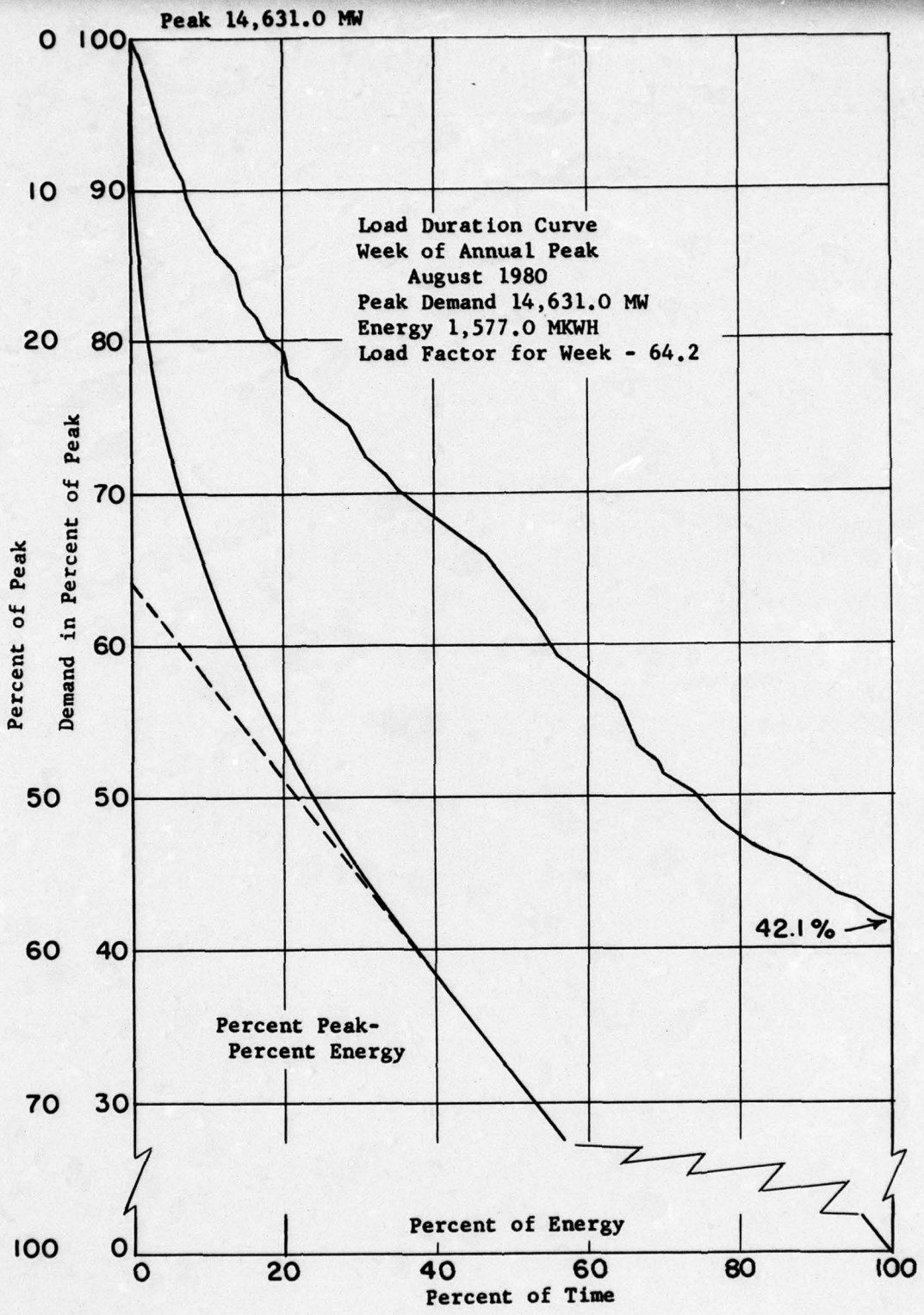
MERAMEC RIVER BASIN STUDIES

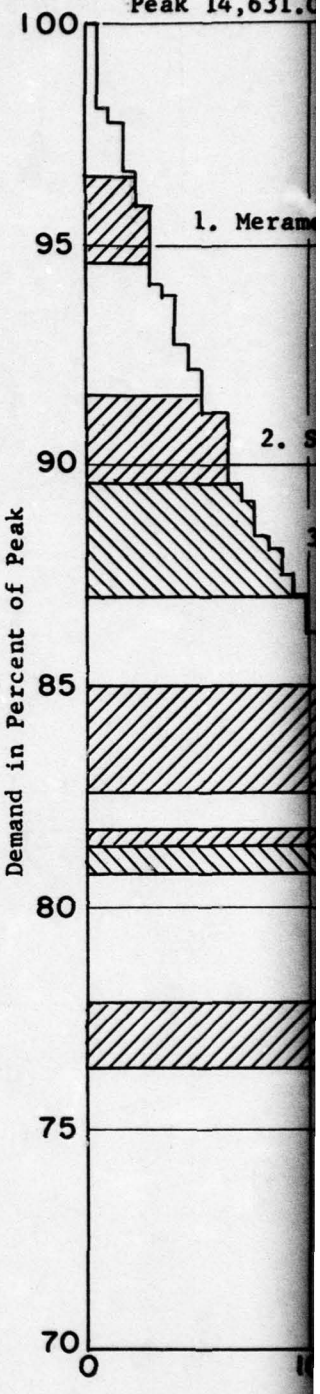
DAILY LOAD CURVE FOR WEEK OF
ANNUAL PEAK - AUGUST 1980
POWER SUPPLY AREAS 15 & 40

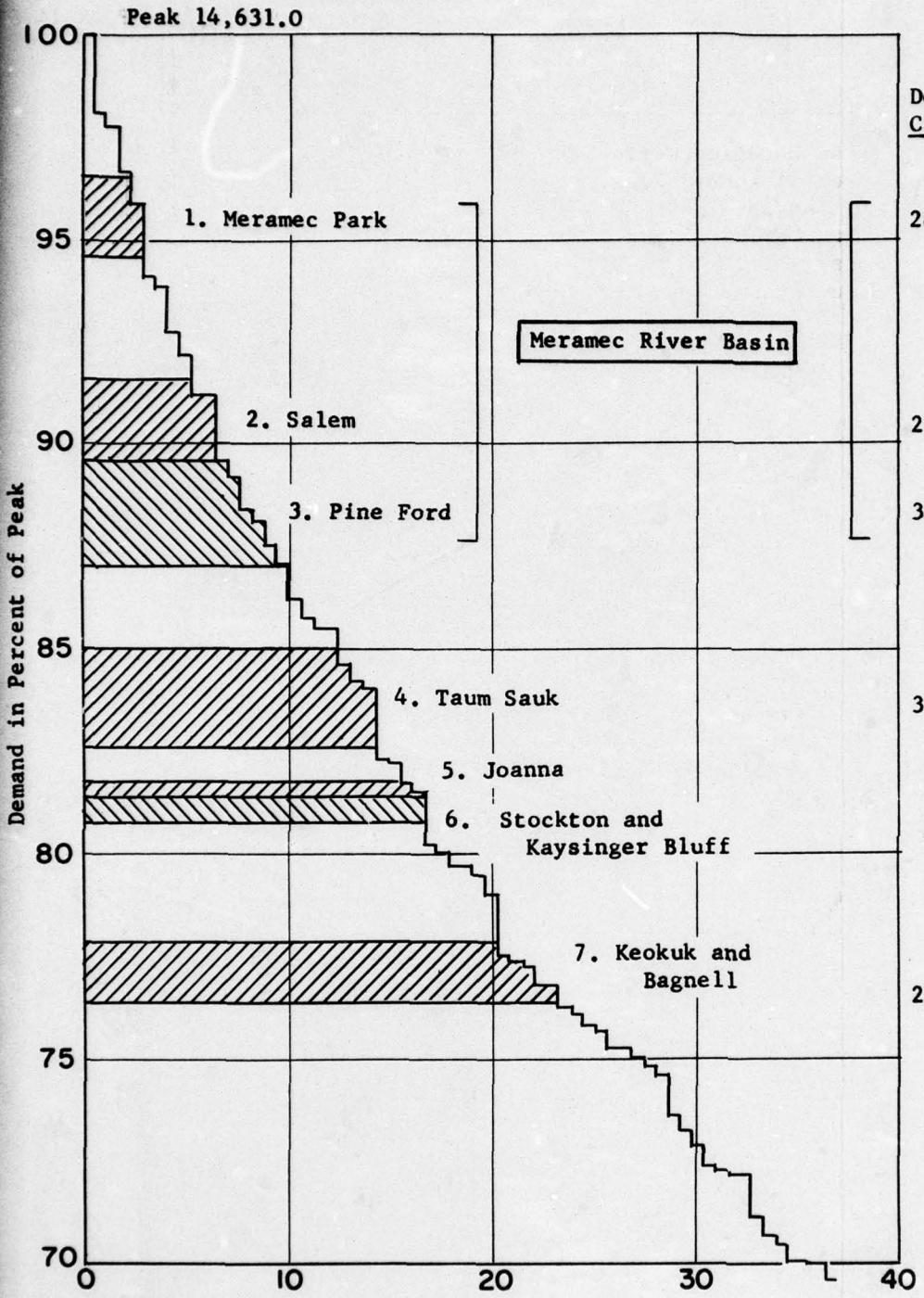
FEDERAL POWER COMMISSION
CHICAGO REGIONAL OFFICE
FEBRUARY 1964

Plate FS-2

2


Peak 14,631.0 MW
Load Duration Curve
Week of Annual Peak
August 1980
Peak Demand 14,631.0 MW
Energy 1,577.0 MKWH
Load Factor for Week - 64.2
Percent of Peak
Demand in Percent of Peak
42.1%
Percent Peak-
Percent Energy
Percent of Energy
Percent of Time
0 100
10 90
20 80
30 70
40 60
50 50
60 40
70 30
80 20
90 10
100 0
0 20 40 60 80 100


Peak 14,631.0
1. Meram
2. S
Demand in Percent of Peak
100
95
90
85
80
75
70
0



	Dependable Capacity-MW	Output MWH
1. Meramec Park	288.0	1,440.0
2. Salem	292.0	3,100.0
3. Pine Ford	380.0	5,320.0
4. Taum Sauk	350.0	8,050.0
5. Joanna	54.0	1,460.0
6. Stockton and Kaysinger Bluff	92.8	2,600.0
7. Keokuk and Bagnell	210.0	7,800.0

30.0% of Peak of Load Duration Curve

MERAMEC RIVER BASIN STUDIES

POWER DURATION CURVE FOR WEEK OF ANNUAL PEAK -AUGUST 1980
POWER SUPPLY AREAS 15 & 40

FEDERAL POWER COMMISSION
CHICAGO REGIONAL OFFICE
FEBRUARY 1964

Plate Fs - 3

Vol 1 - AD36824
Vol 2 - AD36827

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